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POLLUTION ABATEMENT
Through
Soil and Water Management

PROCEEDINGS of WORKSHOP
AUGUST 9-12, 1971

Portland, Oregon

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

USDA-SCS-PORTLAND, OREG. 1971

POLLUTION ABATEMENT THROUGH SOIL AND WATER MANAGEMENT

The Soil Conservation Service has a key role in pollution abatement as it relates to soil and water management. The Administrator has established this as an objective of all Service programs.

OBJECTIVE OF WORKSHOP

The objective of this workshop is to develop an understanding of the technical and administration aspects of pollution abatement. This is to be accomplished through a review and discussion of:

1. POLICY AND AUTHORIZATIONS
2. RESEARCH INFORMATION
3. STANDARDS AND SPECIFICATIONS
4. METHODS OF FINANCING
5. BENEFITS
6. HOW TO IMPLEMENT ASSISTANCE TO SOIL AND WATER CONSERVATION DISTRICTS, LANDOWNERS, CITY OFFICIALS. AND PROJECT SPONSORS.

POLLUTION ABATEMENT THROUGH SOIL AND WATER MANAGEMENT

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PHASE I - PRESENT KNOWLEDGE ON POLLUTION PROBLEMS

TYPES OF POLLUTION RELATED TO SOIL AND WATER RESOURCES

C. E. Veirs

"We travel together, passengers on a little space ship, dependent upon its vulnerable supplies of air and soils preserved from anihilation only by the care, the work, and I will say, the love, we give our fragile craft." - Adlai Stevenson - and I presume the reason water was not mentioned is because it was considered to be a product of the run-off from the land and is influenced by land management. Certainly, it should be included since so much of its utilization is determined by the water quality yielded from the land and upon water resources development and management.

I feel privileged to be addressing this group of managers and experts of the Department of Agriculture in this workshop on pollution abatement through soil and water management, and doubly privileged at being the first speaker to set the stage by providing a review of the types of pollution related to soil and water. Being first is an excellent position because I know that if I omit anything, the speakers on the program following me will be sure and provide the information. At the same time, I can mention pollutants and management situations generally which will be treated in depth later on.

When talking about pollutants, the broad definition would be any action or substance that impairs or damages a use of a resource. This could be water, land or air. The types or kinds of pollutants are many and from varied or multiple sources. Damaging the landscape or the aesthetics of a resource also is polluting since it lessens or impairs the enjoyment by people of their environment. But basically, the pollutants of concern in regard to land and water resources are those that affect water quality. Air pollution can be caused in the management of the land resource by burning of crop residues and weeds or odors produced from animal wastes in their management or mismanagement. The list of pollutants should also include those that have effects on the soil and water resources as well as those produced from their management. Most of these fall in the category of toxic materials and many are airborne, such as sulfur dioxide from industry and burning of fuels, fluorides from industrial plants, and the hydrocarbons, nitrous oxides, and lead from the internal combustion engines of automobiles and tractors. The parameters of concern which may be pollutants are:

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nutrients
salinity
bacteria or pathological organisms
toxic materials such as pesticides, heavy metals, oils
turbidity and sediment
heat
oxygen demand materials (BOD or COD)

In this introductory presentation I will attempt to identify the sources or causes of some of these pollutants and give some idea of the order of magnitude of the problems they cause.

Fundamentally, most pollution is traced back to the Service, that is, people - and the stress they impose on the resources to supply their demands.

More than half the people that have ever lived are now alive. Half of the people now living are under the age of 27.

According to the Conservation Foundation (Washington, D.C.), the world population at various times in history and predicted in the future are:

	Population (in billions)
Beginning of Christian era	1/4
1650	1/2
1850	1
1930	2
1966	3.3
1978	4
2000	6.6

The time needed to double the human population was shortened from <u>1,650</u> years, to <u>200</u> years by 1850, to <u>80</u> years by 1930. With world population now increasing by about 2 percent (70 million) a year, it will take only <u>48</u> years to double again, from 1930 to 1978. Demographers estimate the 3.3 billion total will double by about the year 2000 -- or in just <u>35</u> years!

If the trend were to continue, the next doubling would occur in less than <u>30</u> years, or by 2030 the world population would exceed 13 billion. The annual increase of about 70 million people a year is enough to repopulate the United States every three years at the present population level of about 206 million.

In the United States, the population growth has about tripled since the turn of the century, making the least increase in the decade of the 30's

and the most in the 50's. The present annual growth is about 2.5 million or about enough people to populate 7 cities the size of Portland each year.

	Population (in millions)
1900	76
1910	92
1920	106
1930	123
1940	132
1950	152
1960	181
1970	205

Of equal or even more importance to the population increase is the trend of where the population lives. In 1850, there were four cities in the world with a population of a million, in 1900 there were 15, and in 1960 there were 141. The cities have been growing 30 times as fast as the population, which helps explain the urban problems we have today.

With less people down on the farm there has had to be an increase in technology and efficiency in order to keep up with the demands for food. Even so, if all of the world supply of food were distributed equally, everyone would be malnourished. If the food supply were distributed at the rate of the U. S. consumption, only 1/3 of the world's population would be fed. This year's Nobel Prize winner, who received the award for developing more productive strains of grain, estimates that we have bought only about a 30 year extension of time before many areas of the world face starvation if the population continues to increase or if additional technological advances are not made. Which brings us to the problems of pollution which develop as our resources are used to meet the demands of the populace.

The old adage that an ounce of prevention is worth a pound of cure holds true for pollution control. The most effective and least cost methods of achieving control are those of prevention.

The parameters of pollution were identified before. The activities that affect these parameters in the land and water resource field are: logging, range management; watershed management; mining; construction of roads, housing, powerlines and dams; recreation; wildlife management; water management including reservoirs, canals and irrigation, power production, flood control and navigation; and, of course, one of the major activities, which is that of agriculture with its crop, animal production, farm runoff, irrigation return flows, and forestry and logging. It is these activities that produce the nutrients, salinity, bacteria, toxic materials, turbidity and sediment, heat, and the oxygen demanding materials.

Nutrients include many elements, but ones of main concern are nitrogen and phosphorus. The effect is a stimulation of aquatic growths that choke the flow in irrigation canals and streams, can be unsightly and remove the oxygen from the water in its decay and decomposition. Nitrogen comes from many sources such as human wastes, fertilizers, animal wastes, and by fixation from the air by automobiles and living plants. The effect of nitrogen on the young of animals and man is critical. Limits in drinking water have been set at 10 mg/l. Excess nitrogen in feed has been toxic to calves and cattle. Phosphorus is much more critical in the control of eutrophication, since it is needed in lesser quantities to stimulate growth. However, it is more easily removed from water since it is readily trapped in the soil by chemical interactions.

Comparison of nutrients show that nutrients produced by cattle to be about 12 times and 25 times that of man for nitrogen and phosphorus, respectively. Fortunately, most of these wastes are discharged to land and not to water. The amount of nutrients contributed to our water supplies from fertilizers and other agricultural sources has not been identified since they are introduced in a diffused manner completely unlike the point source from domestic or industrial sources.

Salinity is mainly a problem of irrigation and water management. The concentration of salts by evapotranspiration is one problem but the major source of salinity is from either natural sources or from the solution of salines by water passing beyond the soil moisture system of the plants and dissolving the salines beneath. The prevention of salinity problems requires efficient irrigation methods and systems which limit the passage of excess water either over or through soils. This efficiency would also enhance the conservation and utilization of applied fertilizers.

Toxic materials usually are in the form of organic chemicals applied to control some pests -- either an insect, plant or fungus. More recently, there has been found damage to humans from heavy metals such as mercury or lead. The solution to the problem may be the restricted or prohibited use of some of these chemicals, but in any event it requires the careful use and application of the materials to the target area and careful use and application of the materials to the target area and careful handling in the mixing and storing of the pesticides and careful maintenance and washdown of equipment. Another pollutant could be the release of oil where it could enter either surface or subsurface supplies.

In an exercise of determining the critical pollution in Region X problems of pollution by evaluating their impacts, the ranking was industrial, municipal and then about equal ranking of the water resource development and management of wastes from rural sources, including recreation. The parameter which weighted the evaluation and made the wastes from rural sources of significance was the bacterial contamination from animal wastes and from recreation with the animal wastes being of greater magnitude. Other weighted factors were the organic or oxygen demanding wastes and nutrients. There are more than 4.6 million cattle in the Northwest

Region, states of Idaho, Oregon and Washington. There are more than 150 bacterial diseases affecting animals that can be transmitted to man which include:

Salmonellosis	Anthrax	Brucellosis
Leptospirosis	Tularemia	Erysipelas
Tuberculosis	Tetanus	Colibaccillosis

Others are Q Fever and other Rickettsial diseases. Over 500 animal virus which include cholera and hoof and mouth disease. Numerous fungi and parasites including flukes and worms.

A daily fecal bacteria production of several animals compared to man is:

Per Capita Contribution of Indicator Organisms from Some Animals - 24 hour contribution

Animal	Fecal Coliform Millions	Ratio to Man	Fecal Streptococci Millions	Ratio to Man
Man	2,000		450	
Duck	11,000	5 1/2	18,000	4
Sheep	18,000	9	43,000	96
Chicken	240	0.1	620	1.5
Cow	5,400	2.7	31,000	69
Turkey	130	0.06	1,000	2.9
Pig	8,900	4.5	230,000	510

The daily fecal coliform production of a cow is about 2.7 that of man but a sheep is 9 times as many. Although the fecal streptococci production of a cow is 69 times that of man, it does not compare to that of a pig which is a multiple of 510. Here again, a real comparison of impact cannot be made unless the discharge to land or water is known.

Heat from land use can be increased from the surface return flow of irrigation water. Here again, the management to eliminate returns would solve the problem. Impoundment's of water resource developments can have a warming effect depending on the discharge level of the facility and the depth of the impoundment, and the water management of the storage and releases. Unwanted heat stimulates the growth of algae and speeds up chemical and other reactions but is not desirable for maintaining cold water fisheries. The logging of the protective shade along streambanks in the forest allows the temperature of the streams to increase. Pools formed by logging debris serve to hold the water and allow it to be warmed.

The organic wastes from the production of food is an enormous quantity-not only in the production but also in the process. If the processing wastes were not considered, there still remains a tremendous amount of solid and liquid wastes which have an oxygen demand on receiving waters. One of the biggest potentials is from animal production. It has been estimated that there is two billion tons of animal wastes produced annually in the U.S. with more than half from concentrated areas. The current animal waste production is about 10 times that of human wastes. Cattle total solids wastes production is about 18 times that of man, but the biochemical oxygen demand or BOD_5 is only about 6 times that of man due to the differences in the solids of the cattle wastes which contain more cellulose and lignins than human wastes - and there are other differences. More than 80% of the human wastes are discharged to water while less than half of the animal wastes are from concentrated feedlot situations of which only a part are discharged to water directly. And the amount of wastes will keep increasing. For our population growth of 2-1/2 million people annually in the U.S., somewhere in the world an extra 2/3 of a million cattle are produced to meet the ever increasing demand for beef. Cattle production in the U.S. jumped from 85 million in 1945 to 108 million in 1965. Even more startling in the increase of production (and wastes) during the same time period is the 600% increase of broiler chickens which increased from 365 million to 2.2 billion.

Finally, we are to the parameters of turbidity and sediment. Although these terms are used synonymously, they are not quite the same. Water can be turbid or have its capacity to transmit light reduced by organic material or color and still not be carrying a sediment load. Conversely, a stream could be carrying or moving a large bedload of sediment with a minimum of turbidity. Sediment was intentionally left to last, but certainly it is not the least of the pollution parameters. Sediment fills in reservoirs, reduces recreational activities, smothers fish spawning grounds, reduces the production of fish food, increases costs of municipal or industrial water supplies, in addition to the loss to the land of the topsoil for the most fertile or best soils. The scope of the problem is large. The annual dredging from rivers and harbors in the U.S. exceeds the volume of materials removed during the construction of the Panama Canal or over 500 million tons. Sediment displaces annually the storage space equivalent to a water supply for 5-1/2 million people or enough water to supply 500,000 acres with two acre feet of water for irrigation. In the Willamette River Basin, estimates have been made that about 40% of the sediment produced is from flood flows and bank scouring, 20% is from forest sources, 20% from farm sources, and 20% from urban and construction sources. The sediment is derived from uncontrolled water resources, road building and logging in the forests, farm runoff from cultivated lands, animal grazing of rangelands and recreation vehicles such as trail bikes or four wheel drive jeep type vehicles.

In addition to the plow, axe, and hoof which formerly shared the blame for sediment production, we now must add the bulldozer and the trail bike. But, in addition to the erosion material itself, sediment is an indicator. It indicates the deficiences in the land and water management or other

practices which allowed the sediment to reach the stream instead of remaining in the field or rangeland, or forest, or highway or other construction site. It indicates that if soil can move to a water course, it is evident that the fertilizer, pesticides, salinity, bacteria and organic material is being moved to the stream also.

One fact is abundantly clear-if pollution from land is to be controlled, the sediment must be curtailed by water management as well as land management, and in the case of recreation, you might add, people management. Just as the term of self-contained is used indicating the retention of human wastes in a boat or trailer, total containment of the materials from land must be accomplished by soil and water management practices in order to achieve pollution abatement.

I have identified some pollutants, indicated their sources, and have attempted to quantify some orders of magnitude of the problems. I wish you success in this workshop on pollution abatement through soil and water management as you now proceed to discuss in detail the problems and means for correction.

SUMMARY OF ARS FINDINGS IN RELATION TO POLLUTANTS AS

THEY PERTAIN PRINCIPALLY TO THE WESTERN UNITED STATES

Jan van Schilfgaarde

Pollution and environmental quality are very much in the limelight nowadays. You folks in SCS and we in ARS are on a hot seat more than many other agencies.

As the previous speaker pointed out, runoff is very indiscriminate. It carries with it sediment, nutrients, pathogens, etc. And as such it is one of the major components of the pollution picture as related to our work in soil and water conservation. Certainly it cannot be separated from some of the other aspects. By the same token it also destroys our natural resources, which is a pollution effect adverse to agriculture rather than by agriculture.

You know the story better than I do in this respect. In broad terms, a good conservation plan applied to the land will take care of a great deal of the erosion and, hence, the pollution problem.

To start with, let us pay some attention to the correction of nutrient pollution. Chemical fertilizers are being used at a rapidly increasing rate. We are now using some 7 million tons of nitrogen fertilizer a year, and similar amounts of other fertilizers. This has led a lot of people, of course, to the immediate conclusion that since the amounts are increasing so much, fertilizers must be a major contributor to water pollution and there have been a number of reports which are very damaging to the agricultural land user in this respect. Some of them are well documented, some of them are not.

Now we readily acknowledge that all over the country we find eutrophication of water bodies; in Virginia, in Minnesota, in Wyoming -- you name the state and you can find bodies of water that are really in pretty sad shape. Some of these conditions have no doubt been aggravated very severely by agricultural practices in the watershed, but let's not make any blanket accusations. Let's look for a moment at a couple of lakes constructed by the Corps of Engineers near Lincoln, Nebraska. Stagecoach Lake was completed in 1963. About a year ago Dr. Wadleigh, who was my predecessor as director of Soil and Water Conservation, visited this area and saw very severe water weed growth in this lake. He also saw that the entrance to the lake was swampy, with very shallow water and very flat topography with grasses and weeds and organic matter in abundance. Surely any water that entered this lake after flowing through such an area was bound to be laden with nutrients and contributing to the growth of water weeds.

Very near Stagecoach Lake is Wagon Train Lake, also completed in 1963. Wagon Train Lake shows no signs of algae growth or water hyacinths or

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other weeds. You could hardly call it clear, as you see from the suspended sediment. As a matter of fact, Wagon Train Lake carries on the order of 3 times the soluble phosphorus concentration as does Stagecoach Lake. Why the difference? The watersheds are very similar. There is some difference in size but the soil groupings and land uses are very similar. But look at topographic maps and you find that Wagon Train Lake, which is the non-polluted one in terms of water weeds and algae, is in a relatively steep topography with steep banks without marshes adjacent to the water. The topographic map of Stagecoach Lake, on the other hand, shows some 500 acres of marshland immediately adjacent to the water surface. No wonder then, that Stagecoach Lake is such a sorry sight. But the rest of the story, obviously, is that this is not the result of agricultural practices in the uplands but of the topography and the conditions right along the lake property, notwithstanding the conclusions of the biologists of the University of Nebraska in Lincoln.

We often don't think about the tremendous nutrient depletion of our cultivated soil over the last hundred years or so. In 1918, Marbut estimated that the virgin soils in the contiguous United States contained nearly 10 billion tons of organic nitrogen. Some years later, Jenny estimated that over a period of 50 years we lost some 40% of this organic nitrogen from our soils by cultivation.

The natural processes of nitrification and denitrification, of a dynamic nitrogen balance, in the soil are strongly influenced, of course, by microbiological action and organic matter decomposition. Data from Mandan, North Dakota, indicate that up to 400 pounds per acre per year of nitrogen can be generated in the soils in the north, and this is part of the balance we have to deal with. Another interesting point, if you look at data from other locations, is that as you go further north there is a far greater nitrification rate.

Looking at it from another point of view, George Stanford calculated that on the order of 1.8 billion tons of nitrogen had been utilized from the soil by cultivation since the arrival of the white man, whereas the total amount of nitrogen that had been added to the soil out of the bag has been about 90 million tons since 1900. Quite a little difference.

We are still continuing to rob our nitrogen bank. It is estimated that 4 of our major crops use about 8 million tons of nitrogen per year. Thus, whether or not we contribute to pollution by using fertilizers, we are dealing with a system where the utilization of nutrients is far greater than the amount applied and, furthermore, where many soils are naturally deficient in essential elements. Without the correction of this imbalance, we are not going to be eating as well as we are now.

We know that phosphorus is deficient in many parts of the country and particularly in the West. Phosphorus deficiency is pretty hard on sheep. It can be even worse on cattle. Phosphorus, lambasted as one of the worst pollutants, is also one of the essential elements for any animal growth. It is the primary element in the skeleton of all animals, including man.

Phosphorus also is an essential element in the energy exchange, the metabolism, of man and other animals, without which we could not exist.

Let's look at yet another aspect; let's look at some people that we think of as rather severe critics of agricultural practices and see what they have to say about the situation with relation to eutrophication of the Hudson River.

An article in the March 1971 issue of Audubon magazine pointed out that the central part of the Hudson River receives significant runoff of fertilizer and is virtually the "chamberpot" of some of the major cities in that area. It is also one of the most prolific fishing streams in the Nation. The upper part of the Hudson, on the other hand, is a pristine stream uncontaminated by man's activities. Because of its deficiency in nutriets, it is also "uncontaminated" by fish. That article was kind of a defense of agriculture in relation to water quality. But let's not be complacent. We are all fully aware that there are many cases where we do have problems.

These particular data, (listed below) taken from Bill Johnston in the Central Valley of California, indicate heavy fertilizer loadings in tile drainage effluents, particularly in the rice fields. If you are not familiar with these data and if you are concerned with these problems, I'm sure you would find the study interesting.

FERTILIZER LOST IN TILE DRAINS 1/

Crop	Fertilizer Applied (lbs./acre)		Fertilizer Lost (lbs./acre)	
	N	P	N	P
Cotton-Rice	261	46	109.2	.9
Cotton	196	32	17.4	.2
Alfalfa	0	0	4.6	.3
Rice	84	0	37.4	.6

1/ From Johnston, et. al., S.S.S.A. Proceedings, 1965, Vol. 29, p. 287.

We had an experiment going for a number of years near Riverside on what we called a 1,000-acre lysimeter. It's a citrus orchard near Riverside in a basin underlain by impervious rock and situated so that all the watershed drainage discharges at one point, and thus is readily collected and measured. On this 1,000-acre orchard we have measured almost 50% of the fertilizer coming out in the drainage water, an indication of pretty poor management practices on that particular orchard.

We are not in the clear; far from it.

For a number of years we have been running a series of studies to determine under what circumstances we do have severe losses and what we might do about it.

Studies were conducted at Morris, Minnesota, on nutrient runoff and, depending upon farming practices, there was a fairly heavy loss of nitrogen in particular. This, by the way, reconfirms what Frank Allison found a number of years ago on lysimeter studies. The greatest losses come from fallow unfertilized soil. These same plots also have fairly heavy soil losses associated with poor management practices. I think it is rather important that 90-some percent of the nitrogen loss was associated with the soil loss; not in solution, but riding piggyback on the sediment. The same was true with phosphorus and you already knew that, but I am not sure that you were all aware that this is also the case with nitrogen losses. There seems to be a very close correlation with sediment loss.

We have done similar studies on a small watershed basis in other places, let's turn to Coshocton, Ohio. Unfortunately, I don't have any good data for locations farther west, but I think the data can readily be extrapolated in this case. The Coshocton watersheds have been established for more than 30 years for hydrologic studies and recently have been adapted for study of nutrient losses in water. From a particular 5-acre woodland block, the total phosphorus loss was trivial, in the order of .03 pound per acre per year. The phosphorus concentration was high, normally were the times when the discharge rate was very low. Obviously, the total phosphorus loss is the product of the concentration times the water discharge rate and we have to be very careful in extrapolating point data if you are interested in total annual losses.

Phosphorus loss was significantly greater from farmland than from woodland at the Coshocton location; but, .03 pound per acre versus .06 pound per acre is hardly cause for excitement. This study was made under conditions of good erosion control, where soil loss was maintained at a minimum. Generally, in comparing woodland, general farming, and a small feedlot, nitrogen losses increase in that order, but still we are dealing with very low numbers.

From 30 to 40 years of data on the Rio Grande River, Dr. C.A. Bower found that, notwithstanding an increase in fertilizer use with time, total nitrate load in the river downstream from the irrigation return flow had decreased. This finding indicates, at the minimum, that fertilizer use in this area cannot be blamed for decrease in water quality in the river.

Dr. David Carter's data on the 200,000-acre irrigation project near Twin Falls, Idaho, show that roughly 30 pounds of nitrogen and nitrate was recovered from the drainage water per acre per year. One can say this was way too much, or one can say it isn't very much; it depends on the point of view, and it depends upon how this drainage water is to be used. One could say that the Snake River is darn good fishing water and maybe that the bit of fertilizer that comes out of this irrigation area is helping this. On the other hand, it does indicate relative inefficient use of fertilizer.

An entirely different approach to the nitrogen problem was taken by Harry Nightingale and his colleagues in Fresno, Central Valley, California. They collected numerous samples from wells scattered across some 400 square miles around Fresno County and then plotted the nitrate level in the groundwater across the county. They found, relatively speaking, nitrate levels of no great concern in the groundwater. Frequently, high levels could be explained, for example, by the presence of a disposal plant.

Data from these studies indicate that where nitrate concentrations in the groundwater and in the soil profiles for 20 feet are compared with the cropping practices and whether it is agricultural land versus a municipality and so on, a fairly good correlation was found and pretty good explanations of what was happening. Basically, in those areas where you have intensive cropping, orchards, and high fertilizer use you will find a high level of nitrate in the soil profile down to 16 or 20 feet and a higher level of nitrate in the groundwater than in areas where there is less intensive cropping.

Now taking similar data out of the literature together with the ones he has collected himself, Nightingale did show something that is rather disconcerting, Figure 1. That is, a very steady increase in the nitrate level in the groundwater with time. If you start at the 50% point (recurrence level) and draw a line straight up you find that the nitrate level was considerably lower in the 1950-60 decade than in 1969. On the other hand, the actual numbers show that the average level, even in 1969, was well below the danger level established by the Public Health Service. That doesn't mean that there were not quite a few samples which were well above the 10 part per million nitrate nitrogen level.

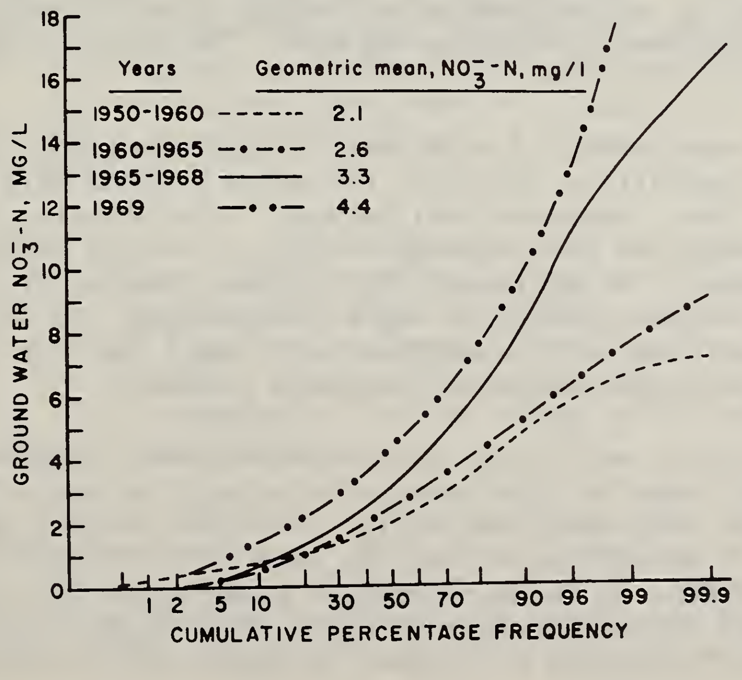

Figure 1 - Ground-water nitrate-nitrogen concentration probability curves, Fresno, California

There are, of course, a number of management techniques that you can use to try and reduce the danger of nitrate pollution to groundwater. One of them is the application of chemicals that make fertilizer less readily available and extend the period of time over which ammoniac fertilizers are converted to nitrate.

Let's switch topics here from nutrients to erosion. If you want a logic to this switch, you might say much of the nutrient pollution, real or imagined, can be controlled by erosion control, so let's look at erosion control for a moment.

Erosion control, of course, is the beginning and at one time was the all of the SCS. Now your program and our program is considerably wider than that. We are rather proud of the progress we have made in helping you folks get some tools towards giving advice and managing erosion on the farm. Most of you are familiar with the misnamed "Universal Erosion Equation," -- misnamed because it is applicable only to the areas east of the Rockies. Yet the erosion equation has been extremely useful in a significant part of the country. Why has it not been used west of the Rockies? There are a number of reasons. One is that the equation was developed originally as a statistical development based on data from east of the Rockies. That was a big enough job for the people at that time.

A second one is that the type of erosion that takes place, say in the Palouse area, seems to be of very different character than that in much of the Corn Belt. As I understand it, in the Corn Belt we are dealing primarily with the kinetic energy of raindrop impact spread out over a good part of the season; whereas, in the Palouse a significant part of the erosion is associated with losses from saturated soils, or in other words, seepage forces, and shall we say, potential energy losses as opposed to kinetic energy losses. However, Walt Wischmeier recently has spent some time in the West and is in the process of trying to see to what extent we can develop a similar tool for use in the West. We hope we can make some progress.

Walt has recently come up with a relatively simple monograph with which he can calculate the erodibility factor, K, for soils and the only data needed are those derived from a standard soil survey. This obviates the need for expensive field studies or rain simulator trials. We are convinced that the erodibility factor K is applicable in the West just as it is in the East. We are also pleased that this way of determining the K value is applicable to subsoils as well as surface soils and, therefore, has direct application to construction sites and suburbia problems.

But I have to reiterate, we do have erosion in the West, and we do indeed need some additional work in this area to be helpful to you folks. This doesn't mean we have completely sat still. We think we have made a good deal of progress. I am willing to buy the advice of our folks in the State of Washington that if we can establish good vegetative cover early in the fall on wheat fallow systems, we can control a great deal of our erosion by agronomic practices as opposed to engineering practices.

Our level terracing work in Iowa has indicated what we anticipated: we do get a significant reduction in surface runoff, but we get a commensurate increase in subsurface flows so that the total discharge for the stream stays about the same. And, as you would expect, soil losses are essentially nil in the level terraced fields as compared with conventional farming.

There are other engineering practices, such as the broad base bench terrace, that can indeed increase water storage tremendously. At Mandan, we have gotten an increase of as much as 14 inches of water stored in the soil profile. Engineering practices are not the only way to erosion control, as you well know. Providing adequate organic matter, plant material, either dead or alive, can be a very effective means of controlling erosion. Now this leads us immediately to minimum tillage or zero tillage.

In Ohio where continuous corn was planted 6 years ago in a row without any tillage, crop yields were maintained and sediment losses were reduced from 2,760 pounds per acre to 21 pounds per acre per year.

Carrying it a step farther, Orus Bennett in West Virginia has been planting corn in sod that has been stunted rather than killed with herbicides. He gets a ton of hay, 28 tons of silage, and after silage is harvested he has a good sod left. This is an area where agricultural production is not far above a zero base. West Virginia, of course, is rich in another way -- strip mining. Heaven for the miner, but hell for the homeowner, and pretty rough for the guy who is interested in a crystal clear stream. Strip mining in the Dakotas, Wyoming, and Utah is under alkaline conditions. The problems are very different in detail but not so different in principle or in concept.

Just spreading the spoil isn't going to do the job. We are just beginning some work on strip mine reclamation in the Dakotas. We have been at it for 3 or 4 years in the East. Careful selection of plant material and fertility work in the greenhouse and in the field have made it possible to grow a rich crop of African love grass on a mine spoil with a pH of 4. We can get good grass cover with a pH of 2.8. This is a little hard to believe, but I have seen it.

It is not a simple problem. Basically, you must make the phosphorus available. It is not an acidity problem *per se*; it is a nutrient availability problem. If you lime the soil to bring up the pH and then apply rock phosphate you don't get any response, but if you use superphosphate and lime together it gets you over the hump; so does rock phosphate by itself, which apparently ties up enough of the aluminum to make phosphorus available to the plant.

We can't leave the erosion picture without paying some attention to streambank erosion and channelization. We have had research in this area for a number of years, but I readily admit that we haven't made as much progress as we should. I only wish we could be more helpful to you. At every meeting with SCS, I have attended in the last year or so, streambank

erosion seems to be number 1 on your list, and I am hearing the message; I hope I can do something about it, gentlemen.

Now that doesn't mean we haven't accomplished anything. Especially in terms of engineering techniques for stopping erosion when it is bad, we do have some pretty good answers. Hollow blocks were first used in cooperation with SCS at Buffalo Creek, New York. These hollow blocks relieve the hydraulic forces of their buoyancy so the blocks don't wash away, and they permit grass to grow through them. They have been in place for 10 to 12 years, and they seem to be holding up very well. You don't have to be that sophisticated. Car bodies and old tires do the job pretty well in Chickasha, Oklahoma, but they don't look quite as nice. There have been a few problems. One of them is, if you don't extend the protection far enough around the bend you can still have undercutting on the ends. Another is that with high floods you can get cutting where the revetment has not been extended high enough or because it has been designed for normal flows.

Wind erosion severely damaged 4.7 million acres on the Plains this last season. We have answers to a point; we are continuing research. We have found, for example, in the last couple of years that the damage to seedlings is much more severe than we thought. We get a high percentage of losses from sand burn on seedlings. Sandblast not only mechanically damages the seedlings but also changes their metabolism. This is something that we were not aware of before.

We are continuing our work in trying to improve protective capability from barriers and other control practices. Again, the rate of work in the wind erosion area is not as fast as it should be relative to the size of the problem, particulary in a damaging year like this one.

Windbreaks such as grass barriers seem to be very successful in wind erosion control and snow trapping, and we and you are under tremendous pressure to extend our work in central Montana. Most of our has been done from Sidney, Montana, in quite a different resource area.

Cattle are being concentrated more and more, and the feedlot problem is very much in the public limelight. We better make sure, gentlemen, that we find acceptable solutions--acceptable not only in reality but also in the public view. When cattle get in water, things happen. Somehow we haven't learned to toilet train them yet. We have learned quite a bit. I am sure Fred Norstadt will be more specific. If we compare nitrate movement below a level feedlot with nitrate movement below a cornfield, we find that there is essentially no movement below a feedlot. Anaerobic conditions at a shallow depth below the feedlot provide a situation for denitrification, and there is essentially no movement of nitrate into the groundwater from the feedlot. On the opposite side of the coin, under cultivated soil conditions you do have a danger of losses to groundwater.

Another question under study is whether we can use beneficially the manure that is collected in feedlots. Yes, we can apply manure to the land; we have known that for centuries. But how far can we go on an economical basis?

We are applying between 10 and 250 tons of cattle manure per acre near Bushland, Texas. If we are careful with our management, we can maintain sorghum yields even at very high levels of application. But this is not necessarily a good answer, because under these very high levels of application we get a tremendous accumulation of nitrate in the soil and a tremendous accumulation of nitrate in the forage so it cannot be fed. No doubt with time we would also get a tremendous accumulation of some other elements. Some of the heavy metals might be more damaging in the long run to our soils than is the nitrate, per se, which can be corrected in a short period of time. I will leave the rest of the story to Norstadt except for one aspect, the dairy situation in Riverside County.

Many of you know that the dairy industry has moved east from Los Angeles and is now concentrated near Chino, California. There, our folks have been measuring ammonia losses to the air as high as 1 pound per acre per day in an acid trap. If I am not mistaken, correcting for the effect of the acid traps, we are still talking about 1/2 pound of nitrate of ammonia losses through the atmosphere per acre per day. It is not a simple process, and it depends greatly on weather conditions. The rate of loss is much higher when the manure pack or the soil is wet and the air is dry under clear conditions right after a rain. In the same area, as much as 9 pounds of ammonia per acre are being deposited in the rainfall. It is running somewhere around 1 pound per acre per inch of rain. In other words, the atmosphere gets to be a major component in the nitrogen cycle in this area. Whether this is good or bad is something I leave to you to decide. There is some indication that if you could speed up the losses of ammonia from the feedlot to the air you might well reduce the groundwater pollution problem without severely increasing the air pollution problem. This may actually be a good management tool rather than one to be concerned about.

Animal waste--human waste. We think we are a little better than animals. I am not sure that is always true. We are different anyhow; maybe we are worse. At Flushing Meadows, Phoenix, Arizona, we are recharging into the groundwater secondary effluent from the city of Phoenix disposal plant. We can maintain rates up to 300 feet per year. With proper management the the average concentration of nitrate in the groundwater after recharge is less than one part per million. Proper management means maintaining a good sod in the recharge basins and using the proper lengths of alternate dry and wet cycles. If this system is put into practice on a large scale, as is now the plan, all of the effluent from the city of Phoenix can be recharged to the groundwater in the Salt River Plain. It can be repumped for reuse either in a municipality or for irrigation, including at the same time recreational benefits. This system can provide for the city of Phoenix roughly one-third the amount of water that the Department of the Interior intends to divert from the Colorado River for the Central Arizona Project. Futhermore, the cost of $5 per acre-foot would be far less than the cost of diversion from the Colorado River.

It is just recently that we have started to pay attention to the other aspect of municipal waste, namely sludge. With municipal sludge as with animal manure, there is the potential of reapplying it to the land to get

beneficial use rather than a headache. We are concerned on the other hand with the number of potential problems such as high accumulation of certain minor elements. We have gotten as much as 55 parts per million of cadmium from the analysis of some dry sludge. Cadmium is a metal which does not seem to interfere with plant growth and, as I understand it, is readily transported and accumulated in plants; but it raises the roof with humans if they eat the plants that have grown under such conditions.

Salinity is another aspect of the pollution problem that we cannot ignore. Many farms in the Dakotas and elsewhere have been abandoned because of improper management of saline soils. The type of problem that we have heard the most about recently in the Plains has been that of saline seeps. The total land affected by salinity in these Northern Plains States runs somewhere around 20 million acres. In Montana, it seems to be concentrated primarily in two areas around Great Falls and around Culbertson. Particularly under summer fallow, we are not getting full utilization of the water on the upper part of the watersheds. Therefore,we get excessive drainage, which comes out again at the bottom of the hillside, where after evaporation, the salt is left behind. The salt changes the permeability of the soil so that less water can seep through and drainage becomes less efficient. In Montana, the area affected is increasing at the rate of 10,000 acres per year.

One doesn't always find out if he has a seep spot problem until it is fairly easy to see where these seep spot problems are. Different crops use water at different rates. If we have a severe problem with saline seeps under summer fallow conditions, cropping to wheat would use significantly more water and, therefore, reduce the saline seep problem. If we can pick our crops in such a way as to increase water utilization, we again would reduce our saline seep problem. Chances are then that agronomic practices and crop rotations will be the primary solution to the saline seep problem as we see it at present.

In the Lower Rio Grande Valley, salinity problems of an entirely different nature are resulting from poor drainage. A typical, but rather expensive, solution to this type of problem is subsurface drainage. Within the last year or so, our engineers have found that they can install plastic shallow well points, tie 10 or 12 shallow points together with a plastic manifold, put one small pump on it and get good drainage out of the sandy aquifer to relieve the soil of hydrostatic pressure. The drain effluent is a horrible brine. This system alleviates the problem at a cost far less than that for standard subsurface drainage.

This is an example of pollution to agriculture rather than pollution from agriculture, until you start talking about disposal of the brine. Then you are back up the same creek. How do you get rid of it?

This was one of the problems that caused us to close out a project in North Dakota, where we found a good solution to the salinity problems of the Red River Valley of the North. The solution is to reduce the piezometric pressure in the underlying aquifer by relatively low volume pumping

then to dump the brine in the Red River. The only trouble is that the river crosses an international boundary, and it might be a little bit unpleasant when the salt load hits the Canadians.

Salinity problems, as I just pointed out in the drainage case, call for good water management, and good water management also results in less of a problem in pollution from nutrients, salinity, and a variety of other things. Not only that, agriculture is under the gun as the greatest consumptive user of water. By the calculation of some economists, we would be far better off if we used all of our water to make bourbon because the value per gallon would be much higher than if we put it on the land for irrigation.

Some experiments at the Salinity Laboratory in Riverside compared three types of irrigation: furrow, sprinkler, and drip irrigation. The same rate of water application was used in each case -- the equivalent of a quarter of an inch per day. But in the case of the furrow, it was applied once a week at 1-3/4 inches. The water used is at two salinity levels, 200 and 2,000 parts per million. The crop yields with drip irrigation were very much higher than with the sprinkler and furrow irrigation. The differences were greater with the low quality water than they were with the high quality water. Now there are some caveats to this experiment, but I don't have time to go into them. The point still holds that drip irrigation holds a promise of being able to make better use of a limited water supply while at the same time alleviating salinity problems.

Another aspect of water management concerns tile clogging. Manganese and iron deposits are not very popular either in Southern California or Florida. In Florida, some tile systems have failed within 6 months.

One of our fellows had a bright idea; he thought that if you could only maintain anaerobic conditions in your tile systems you could keep your iron and manganese ions in solution and they would wash out so that you wouldn't have any deposit problems and could keep the line open. I am not sure whether that is going to work or not, but gentlemen, something else will work. If you turn the tile outlet up, you will establish anaerobic conditions and you are bound to reduce the nitrate load, thereby alleviating the nitrate pollution problem. When we field tested this idea at Firebaugh, California, we unfortunately selected a site that was intercepting natural groundwater containing in the neighborhood of a thousand parts per million of nitrate. We reduced the nitrate, but the stuff coming out wasn't exactly culinary in quality.

One cannot talk about pollution without mentioning pesticides. One cannot talk about pesticides without being concerned with social and political implications as well as technical ones. I will just introduce the subject. I am taking one very small segment here as an example. This one is from New Mexico and, as such, is of concern to you folks here in the West.

The caterpillar has invaded New Mexico. I understand that some 2 million acres are about to be eaten up or have been eaten up this last season by an outbreak of caterpillars. The caterpillar eats everything that comes in his way. It is a sociable creature. An awful lot of them gather in a small

space. What's left after dinner doesn't look so good.

All right, the choice is between using toxaphene to kill the caterpillars and keep the grass cover and running the risk of getting some toxaphene in the Canadian River or not using toxaphene and ending up with denuded soils so that the soil can end up in the Canadian River with the toxaphene that was applied last year. You make the decision.

It would be nice if the caterpillar was like the screwworm. The screwworm mates only once a year. To develop good control techiques against the screwworm is very important because the screwworm is very hard on livestock, whether it be goats, sheep, or cattle. By sterilizing the male by radiation techniques and then releasing millions of males in the infested area at a time when the females are mating, the number of offspring drops drastically. The screwworm has been eliminated from Florida and very much reduced in some other States in the Southeast. Unfortunately, not all animals are so accommodating that they mate only once a year. Maybe if we could teach them that, we could control them, as well as the problem of the human population explosion.

Turning now to some research implications as opposed to the social,political question, we have been doing quite a bit of work across the country with pesticides. In Ohio, we have been studying the fate of the dieldrin on cropped fields. I'll mention the latest result first. It developed as an afterthought from a repeat experiment, conducted because the original data left quite a questionmark. Only 65 or so percent of the dieldrin that left the spray boom hit the soil. About 35 percent of the dieldrin was volatilized between the spray boom and the soil! That is a problem I am sure something can be done about, although we consider it a machine design problem outside our area of responsibility.

The amount of dieldrin in surface runoff water where erosion was controlled was negligible, in the order of 0.02 percent of the amount of dieldrin applied to the soil. On those plots where there was erosion there was a loss on the order of 2 percent of the applied dieldrin. That is 2 percent of the 65 percent that got there, remembering the 35 percent loss. A similar or somewhat larger amount was lost by volatilization during the first season. These volatilization studies turned out to be very tricky and we called on the expertise from our microclimatology group in New York to measure vapor pressure density gradients from which the volatilization rates could be calculated. Thus, it was determined that between 2 and 3 percent of the dieldrin that reached the soil was later lost to the air.

This finding fosters a number of considerations. For one thing, it confirms that much of the dieldrin found in the plant is not absorbed by the roots and transported through the plant system but is abosrbed by the leaves directly. And it also shows that the greatest single loss under good management conditions of some of the chlorinated hydrocarbons is direct volatilization to the air. That may be why Rachel Carson could talk about DDT concentration in Alaska; not because of any water circulation, but because of air circulation.

I tried to tell you just now that pesticide losses under good conservation practices were not severe in the runoff water. I also said at one time or another that nutrient losses frequently were not as severe as some people have tried to make us believe. I want to make sure that you don't take an attitude of complacency because, gentlemen, we have some very valuable resources to protect.

What I have been trying to tell you then, in summary, is that water runoff and resulting pollution from sediment, pesticides, fertilizers, and other noxious materials must be controlled. Such control will go far towards reducing pollution from agriculture to a reasonable level.

Good conservation practices as we know them now, with additional modifications and innovations, will go very far to answering these problems and that, of course, is where you folks come in. With good conservation practices every stream will run clear and less contaminated than we see it today.

SUMMARY[1]

THE IMPACT OF SPECIFIC POLLUTANTS ON THE

ENVIRONMENT -- SEDIMENT, HEAT

Richard J. Janda

The impact of sediment and heat on the environment is enormous. The annual cost of dredging sediment from our nation's waterways is about 500 million dollars, for removing excess turbidity from public water supplies about 14 million dollars, and for lost storage space in water-supply reservoirs about 50 million dollars. These three items alone attest to the tremendously adverse effect of sediment on our national economy. Many of the effects of sediment and heat, however, cannot be presented in quantitative or economic terms. For example, what is the "cost" of the silting over of a gravel spawning riffle, or of the human discomfort associated with increased summer air temperatures in urban areas?

Sediment and heat influence the environment in so many ways that they cannot all be enumerated in the time available. Instead this presentation concentrates on the principles and properties of sediment and heat that generate recognized environmental problems.

SEDIMENT

Sediment is transported by ice, wind, gravity, and liquid water. These agents erode about 4 billion tons of sediment in the United States each year; about half of that amount ultimately moves into major rivers. Some estimates suggest that as much as 70 percent of the sediment in our rivers is the result of some form of man's activity. Furthermore, the Environmental Protection Agency has indicated that sediment pollution is the most prevalent form of water pollution. Because of the magnitude of environmental problems associated with water-transported sediment, and because my personal experience is limited to this type of problem, this presentation focuses primarily on problems related to the concentration and type of sediment transported by or deposited in various bodies of water.

In passing it is worth noting that although most sediment-related environmental problems involve sediment transported by water, many interesting and costly environmental problems are associated with accelerated mass movement and aeolian activity. Acceleration of mass movement processes may result from disturbing the thermal regime of permafrost, from over-steepening slopes, and from application of irrigation water. Intensification of aeolian activity most commonly is associated with injudicious removal of stabilizing vegetation on loessial soils and sand dunes.

1/ Summary of an illustrated lecture. Publication authorized by the Director, U. S. Geological Survey.

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Traditionally, environmental concern about water-transported sediment has centered mostly on the fact that much of the sediment represents the loss of potentially productive agricultural soils, and on the loss of space and operating efficiency resulting from deposition of sediment in reservoirs and conveyance channels. These problems involve the total amount of sediment transported by a stream. However, many more subtle but equally perplexing environmental problems (for example, deciding the ultimate fate of radionuclides and agricultural pesticides, maintaining suitable spawning beds for anadromous fish, and designing bridge crossings, conveyance channels, and water treatment plants) can be understood only by studying specific types and sizes of sediment, and by studying the mode and frequency of sediment transport.

Most sediment in streams and coastal waters is ultimately derived from soils and other surficial deposits and, therefore, is (at least initially) composed not only of particulate mineral matter but also of organic litter, microbial life, adsorbed cations and organic molecules, and cultural artifacts associated with the parent materials.

For the purpose of reviewing and standardizing nomenclature, types of sediment and their dominant mode of transport are summarized in the following table:

Dominant Mode of Transport	Sediment Type (grain size)	
Suspension	Clay	(<.002 mm)
	Silt	(.002-.062 mm)
	Planktonic organisms	(.005-.250 mm)
	Finely particulate organic debris	(<10 mm)
Either suspension or bedload	Sand	(.062-2.0 mm)
	Coarse organic debris	(>10 mm)
Bedload	Gravel	(>2.0 mm)
	- frequently transported	
	- infrequently transported	

"Frequently transported" gravel is gravel-size material that normally moves as bed load. "Infrequently transported" gravel, in contrast, normally does not move except during extreme floods of long recurrence interval; such gravel does, however, form an important element of bed roughness and a significant niche in the fresh water habitat. Specific environmental problems are, moreover, often related to the mineralogical or chemical properties of the sediments, especially those of finer size fraction.

Environmental problems involving water masses transporting too much sediment are related to the following deleterious properties of sediment:

1. To fill, obstruct, cover, or bury

2. To abrade

3. To be toxic or to transport toxic substances

4. To alter aesthetic values (stain, "dirty," smell)

5. To impede light penetration

6. To consume oxygen

7. To alter physical properties of the existing sediment mass

8. To provide nutrients for undesirable organisms

Not all sediment types possess the same combination of properties nor do all sediments possess each individual property to the same degree.

Under special circumstances, some types of sediment may also possess the ability to set in motion processes that will result in the dramatic addition of still more sediment to a water-sediment mixture. Coarse organic debris (branches, tree trunks) and boulders may plug a stream channel to the extent that it will leave its established course and carve an entirely new channel. Addition of fine sediment in extremely steep watersheds may increase the density and viscosity of a water-sediment mixture to the point that the competence of a stream may actually be increased and result in scour of the stream bed and banks.

Water with too little sediment, in contrast, can also trigger serious environmental problems because of increased ability to erode previously deposited sediment and because of increased light penetration in areas where light was previously a limiting factor in the growth of algae.

Examples of environmental degradation resulting from the transportation and (or) deposition of abnormal amounts of sediment can be found in the following environments:

1. Inland rivers and lakes

2. Inshore and coastal waters

3. Water-resource development projects

4. Urban and suburban areas

5. Agricultural land

6. Highways

The impact of sediment is commonly greater in coastal waters than in inland waters because of the greater residence time of the sediment and because of man's greater reliance on marine waters as avenues of commerce and as a food source.

Theoretically, two distinctly different types of sediment-related environmental problems are (1) those resulting from man's inability to recognize and to cope with natural restraints on his activity, and (2) those resulting from man's altering the natural environment in a way that is detrimental to his own well being. In practice, however, distinguishing between these two is difficult, and many exasperating lawsuits and legislative debates have revolved around this distinction. Difficulty results mainly because too little is known of natural environments. Finding pristine watersheds in middle latitudes is difficult, if not impossible, because of the prevalence of cultural influences; moreover, the benefits to be gained from studies of undisturbed areas have been appreciated only recently. Sediment records for pristine watersheds are, therefore, few in number and of short duration. Geologic data can under special conditions be useful in placing limits on natural rates of erosion and (or) deposition; examples are provided by (1) volcanic and coastal landforms that can be dated and reconstructed with reasonable accuracy, and (2) clastic sediments of known age in "closed" depositional basins.

SEDIMENT-HEAT INTERACTIONS

The sediment concentration and temperature of a water mass are interrelated in at least two ways. First, temperature affects the density and viscosity of water and, thereby, can change water's ability to transport sediment. Significant fluctuations in sediment transport rates are often associated with seasonal and secular changes of stream temperature--higher rates being associated with lower temperatures. Second, suspended sediment can affect the temperature of a standing water body. This control results from the fact that floating and suspended particles absorb heat more rapidly than water but in turn radiate heat to the surrounding water, increasing its heat content. Increased sediment concentrations thereby tend to increase the average temperature of shallow ponds, but may actually decrease the average temperature of deep lakes by impeding the penetration of solar energy and by concentrating that energy near the surface where it is more likely to be depleted by evaporative cooling.

HEAT

Environmental effects of increased water temperature are the subject of active research, debate, and controversy. Controversy is perhaps best documented by the existence of a large school of thought that refers to the subject as "thermal enrichment" rather than by the more widely used term "thermal pollution."

The thermal-enrichment school emphasizes (1) the well-known relation that the rate of organic reactions approximately doubles with every ten-degree rise (Celsius) in temperature and (2) the belief that organisms

can acclimate themselves faster and more completely to elevated temperatures than to depressed temperatures. Biologists associated with marine aqua-culture have assembled impressive evidence showing that under some circumstances selected organisms attain "marketable size" much more quickly in thermally-enriched waters than in waters of normal temperature. Other benefits associated with increased water temperature include expanded recreation potential and lessened freezing of navigable waters.

In general increased water temperature is not beneficial to the overall environment. Deleterious effects of increased water temperatures include the following:

(1) Exceeding the lethal upper tolerance limit of temperature for certain organisms

(2) Influencing adversely the form of development of some organisms

(3) Decreasing the solubility of gases, especially oxygen

(4) Increasing metabolic rates of organisms, leading to increased oxygen demand and increased consumption of toxic substances present in the water

(5) Increasing activity of pathogenic organisms

(6) Increasing toxicity of some substances

(7) Increasing evaporation and thereby causing excessive water loss, increased concentration of dissolved solids and possibly localized climatic changes

(8) Producing or intensifying thermal stratification

(9) Decreasing utility for industrial cooling.

Many of these factors can operate synergistically. For example, consider a cold-water fish subject to water of higher-than-normal temperature. The metabolism of the fish will speed up and require more oxygen, but less oxygen may be available. This combination may weaken the fish and make it more vulnerable to attack by pathogenic bacteria or toxic chemicals. The elevated temperature will also have increased the activity of the bacteria, and thermally induced evaporation may have concentrated the toxic chemicals.

The overall effect of thermal pollution is usually not to create an azoic environment, but rather to replace the original assemblage of organisms in a given habitat with another, possibly less desirable, assemblage.

NUTRIENTS FROM ANIMAL WASTES

Fred A. Norstadt

INTRODUCTION

If we rephrase the statement of the title as a question--"What is the impact of nutrients in animal wastes on the environment?"--we can immediately generalize an answer that such wastes provide the vehicle and mechanisms for a large fraction of the transformations of matter and energy in the life of earth--the simple principles nearly every youngster learns about in primary and secondary schooling.

Our problems in snimal waste disposal are not the principles but rather our ignorance that an accounting of our activities will be and is demanded by a niggardly nature. That nebulous entity, Nature, is geared to handle wastes from animals and plants via myriad (even untold numbers of) decomposition and transformation processes. Man sensed the existence of these principles long before he began to examine and demonstrate their qualities.

Soil is a natural depository and repository for the products from all living things. Soil has cleansing mechanisms: chemical, physical, and biological which are suitable for detoxifying most loads.[1/] It is when we exceed or do not understand what soil can do and the optimum conditions for its functions that we get into trouble. We are cognizant of some problems in dealing with animal wastes. Of others we vaguely know something is awry.

It is plain that action is demanded. It is a fact of man's disposition that he will harken to a new cry. As Daniel A. Poole stated in an editorial in the March-April issue of the Journal of Soil and Water Conservation (7), "The public cares less about the technical aspects of soil conservation, forestry, wildlife, or any other discipline than it does about their environmental effects." But, environmental improvement surely will be based upon sound and continually perfected technical knowledge, and what is equally important, although we often neglect them, each generation must be taught anew.

1/ If you examine references (1) and (18), you will note a marked similarity in the scope of discussion as well as in the nature of the biological processes. The two texts illustrate that we have had the knowledge and the tools to cope with many of the problems we now face in dealing with animal wastes. We just have not been forced to turn to them before.

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SOME DEFINITIONS

Nutrients - We shall concentrate on plant nutrients, primarily the mineral elements in several compounds such as nitrogen, phosphorus, potassium, calcium, sulfur, and minor or trace elements, examples being iron, copper, zinc, maganese, and so on--those elements essential for plant growth or toxic to plants in sufficient quantity.

Animal wastes are highly unstable, that is, they are subject to attack by a host of microorganisms, arthropods (including many insects), and succeeding secondary and tertiary life of which we know little. In fact, the wastes are well on the way to becoming manifestly changed as compared to the animal's ration the moment they are voided. A complex microflora and microfauna in the animal's gut has transformed the ingested food. Hence, we can examine, with any success, only thos secondary, tertiary, and later products--generally the simple compounds--evolving with waste decomposition and any effects of these new materials on the environment. Most of these materials are compounds or ions belonging to compounds. The vast majority of them are capable of affecting plant growth in some way.

Animal Wastes - What animals? Chickens, turkeys, cows (dairy and beef), swine, lambs, and horses? These categories are major ones, but numbers of smaller animals could be important. And I presume to exclude human body wastes from my discussion. Understandably, each animal produces wastes unique, yet there is the common thread of life running through all of them.

"What goes in must come out" applies to all domestic as well as wild animals. Including all volatile and nonvolatile products of the many transformations, everything consumed by the animal and not used in adding to body mass must be excreted. Feces and urine are the major excretory products from mammals, but we could include hair, skin scales, skin excretions, in the animal's breath, carbon dioxide, hydrogren, methane, and maybe even some nitrogen oxides. Each animal and its wastes would be a complex study.

Environment - This term includes the total surroundings composed of the three phases: gas, solid, and liquid--the air, soil, and water and whatever is in them. The three phases intermingle and interact in surprising ways. For example, ammonia in the air, when absorbed in the water, could become ammonium hydroxide or absorbed in the soil moisture become the ammonium ion on the soil exchange-complex.

Let us consider the animal with which I am most familiar, the beef heifer or steer of about 1000 pounds placed in the feedyard to finish for slaughter. It is a big animal capable of converting large quantities

of vegetable matter from the land into our subject problem concurrent with forming our red meat. To consider the topic "The impact of nutrients in animal wastes on the environment" separately from the topic "The relation of animal wastes to land use management" is difficult. The reason is clear: What animal wastes can do generally depends upon their management! One of the most clearcut examples of the role of management is that of the effect of water content of the feedlot surface (12). With a moist lot and appreciable downward water movement, into the soil, about 80 percent of the nitrogen contained in the urine is retained by the soil and nitrified. Little of the urine nitrogen escapes to the atmosphere as ammonia. On the otherhand, with a dry lot surface, tightly sealed by animal traffic, nearly 90 percent of the urine nitrogen is released to the air as ammonia.

At the outset, let us get a perspective of organic waste. There is no waste organic material in the natural world (11). Each new product becomes the starting point of another transformation. As Major Bowes used to say on his radio program "The Amateur Hour," "Around and around she goes, and where she stops no one knows!" We label the excreta of animals waste and consider it offensive. It is not orderly in our sense of values. You were taught that compounds making up living bodies and compounds coming from metabolism must be returned to a condition in which they again may be used to build, repair, or provide energy for other protoplasm. We long have taught in numerous courses, at all levels of education, that without a system of reducing organic matter to a form re-usable again and again, almost all life would shortly cease on this earth. We long have given lip service to the scheme of life in the cycles portrayed in the textbooks, but now we find also we must turn our feet, habits, and pocketbooks to the task (9).

At the same time we make pronouncements of pollution by large cattle-feeding activities or other animal enterprises, we overlook smaller, less obvious contributors to problems of soil, water, and air. Perhaps you are aware of the large areas of mountain meadows in the western states with plenty of water, and cows, and manure in the water. Can you recall seeing farm lots by the edge of streams? Or a horse corral on a water course in town? Obviously, even with considerable finesse in management of large cattle-feeding operations, the pollution from domestic animals in other situations may be significant. For example, numbers of horses at their low point in the late 50's were about 3 million, down from a high of 21 million in 1915, but the numbers increased to 7.5 million in 1970, and it is predicted there will be 12 million by 1980, located in or near town and cities and used by the dwellers for pleasure. Or consider dogs and cats. If you look at the grocery shelves in nearly any supermarket, the variety and quantity of pet foods challenges the size of the breakfast cereal display. One further reflection: Consider the situation with water (lakes, streams, and ocean) in that the normal inhabitants do the equivalent of defecating and urinating in those waters and we humans are perfectly willing to swim, get water supplies for drinking and irrigating from those and even eat those creatures, we are accustomed to eat, without any qualm and hardly a thought of their activities.

Do the wastes from all the sources which we control fit into the environment, that is, can the natural environmental processes handle the wastes without being overloaded, or will they be moved to a new equilibrium detrimental to what we regard as normal and right functioning of the system? It is plain that we shall forever be treating the symptoms, unless we get at and control the primary causes--that of the spiraling human burden and man's insatiable selfishness and desire. It is plain that we cannot control all the animals producing wastes, nor would we care to, but I think at times we need to stand back to get a better perspective.

At local, state, and national level, those individuals or groups having the responsibility for making policy decisions have need for technological and economic information--assistance, if you will, in educating themselves (11). There is need for education of the general public. If the demand from the agriculture industry is eggs, meat, and milk from nuisance-free operation, then the consumer must be willing to pay the price. We cannot have our cake and eat it also. We have the capabilities and technical know-how or can develop them to manage animal waste in an acceptable manner. The general public must be shown that manure, in large quantities as well, is produced along with eggs, meat, and milk.

Well, what are the conditions that have motivated experimenters and others to start wading about in feedlots collecting samples and then smelling-up otherwise perfectly decent laboratories? Livestock operations of all sorts are specializing and concentrating animal production and therefore generating large quantities of manure in smaller land areas. A look at the balance sheets of the publicly-owned corporations shows good to excellent return on investment. The economies of scale are not likely to be abandoned unless compelled by legislation or regulation in the name of pollution control (17). Gradually, the smaller family operations are being competitively forced out of the game, and at the same time the problems of wastes and other nuisances are generated. Technological changes lowered costs of mineral fertilizers, depreciating the value of animal manures. Experimenters unwittingly have showed that mineral fertilizers could replace animal manures and maintain crop production.2/ Even cultural attitudes probably have had a hand in weaning

2/ People argue that since commercial fertilizers have become relatively cheap, a ton of average wet manure contains only about $1 worth of nutrients and therefore is not worth hauling and spreading (16). Since it does have to be scraped up and hauled somewhere, the argument that it is not worth putting on the land is not valid. The old established feeding areas, such as the Corn Belt and northeastern Colorado, have little trouble in disposing of manure, but new areas as in southern California and the panhandle of Texas do. Cattlemen in the latter areas seem to prefer to make mountains of it. Historical, if not cultural, attitudes have something to do with the disposal of manure. Perhaps people in the old established areas have learned that there is some value of manure in maintaining soil productively other than just adding N, P, and K.

the tiller-of-the-land away from a balanced livestock-grain farm. Mom and Dad worked, sweated, and sacrificed to send son and daughter to college, and the migration was accelerated. No doubt many factors contributed to the changes in farming and food production in the last 40 years. Now society is changing more rapidly than ever and social pressures on urban areas will not allow livestock enterprises to produce dust, odors, flies, and other nuisances that degrade present environmental quality.

Where are the cattle specifically and how many of them? There are four areas of concentrated feeding (17). No doubt similar maps could be devised for other animals, using the data from agricultural statistics. One area is in southern California and Arizona. The number of lots with more than 16,000 head capacity rose from 23 in 1962 to 36 in 1968. The area that has grown most spectacularly is in the panhandles of Texas and Oklahoma. The number of lots with more than 16,000 head was 33 in 1968, up from none in 1962. The third area lies from eastern Colorado through Nebraska to the North Dakota line. There were 10 lots with more than 16,000 head in 1968. The fourth area is in the central cornbelt. In 1968 there were no operations with over 16,000 head. It is estimated there are over 66,000 feedlots in 7 of the 10 Missouri Basin states. The cattle, hogs, and sheep in the basin excrete wastes equal to 370 million people. If only 5 percent of the animal waste reached streams, the biological oxygen demand (BOD) would be equal to 18 million people. The basin has 7.9 million people (16).

To mentally grasp the pollution potential of a feedyard, consider these two comparisons: One, imagine a situation where 1 million people are crowded together in an area of 320 acres. In terms of biological oxygen demand (BOD) of waste, the numbers of cattle on many feedlots could be equated to a human population of that magnitude. Two, past agronomic studies of animal manures in connection with soil properties and plant nutrition used manure in the order of 10 to 20 tons per acre annually. This rate means adding approximately 120 lbs. of N, 9.5 lbs. of P, and 51 lbs. of K per acre annually. In contrast, the soil of a feedlot receives approximately an 800-fold increase of these materials, depending on the stocking and removal practices. Under such an onslaught of salts and organic wastes, we should expect marked changes in soil properties and behavior of chemical elements in the soil. These comparisons dramatize that never in history have we brought together such a mass of breathing, kicking, chewing, belching, rumbling, excreting life on the land surface. It should be pointed out that public health authorities are not yet concerned about such concentrations of animals posing an unusual threat to health of workers and neighbors. However, a homesite near a feedlot may not be in a pleasant or aesthetic environment.

Let us examine the gross checmical constituents of cattle feces and urine in Table 1. Some of them of significance in pollution are shown on a daily basis per 1000-pound animal, total for a 140-day feeding period per animal, and for an acre of feedyard stocked for a whole year with

360 animals. There can be variations from these values, but they illustrate the problem size. Animal manures and urine probably contain thousands of compounds about which we know little from the standpoint of public health and pollution. Further, these substances in the manure are soon transformed into a long series of successive decomposition and resynthesis compounds. There appears to be little reason so far as we know to fear these "unknowns" since thousands of people work or live around cattle and feedlots. After all, man long has been closely associated with his domestic animals.

There are a host of diseases caused by pathogenic microorganisms known to infect man and animals in common (2). Very recently, in the southern United States, there was an outbreak of a serious epidemic of a virus transmitted to horses and man by common mosquitoes, the disease called sleeping sickness. I believe the example indicates the potential hazard of which we need to be aware and against which we need to act defensively. Diseases common to man and his domesticated animals include those classed as enteric pathogens such as bacteria, rickettsia, mycoplasma, viruses, fungi, and protozoa, and many kinds of worms. The ultimate disposal of farm animal wastes, feces, and urine, must provide for sanitary disposal to prevent new cycles of infection. The kinds of these disease agents in feces and urine is usually unknown. Much additional study is needed. Certainly anyone working or experimenting with manures should have their tetanus booster injections once a year and observe the techniques and practices of handling pathogenic materials. I have heard a veterinarian state that over 100 diseases are common to man and farm animals. One more point related to this area of discussion: Man has steadily been increasing his gene pool of serious allergic reactions to substances that a few generations ago perhaps were not very serious except to a small minority.[3/] Modern medicine has enabled survival of individuals with defects of an allergic nature. Thus, each generation is more sensitive to a wider range and lower level of irritants. Concentrations of animals generate a wide array of organics many of which are allergens to man. This aspect of animal-generated pollutants has received little attention. Specifics are unknown.

Why are the constituents listed in Table 1 significant in pollution? If the organic matter gets into water, about 20 to 30 percent of it is readily decomposed by microorganisms that use oxygen, the BOD of waste. The resulting low oxygen concentrations in water and toxic concentrations of ammonia kill fish. The dry mineral matter is largely soluble salts and gives an idea of the salt load. A corral is a salty place. The runoff can be high in salts. Very heavy applications of manure on land can accentuate a salt or salinity problem. In some areas, feeders add 1 percent salt to the ration to control urinary calculi. Then there is an enormous amount of salt to deal with and much of the salt is sodium chloride that can damage the structure of soils with heavy manure applications. Nitrogen and phosphorus could contribute to the eutrophication or overenrichment of water leading to noxious algal blooms. Such

3/ Dr. G. E. Stafford, personal communication.

overgrowth causes bad taste in water, damages it for water sports, and uses up the oxygen when the algae die and decompose. Nitrogen, present in the early stages of decomposition as ammonia and amines, also can be converted to nitrate by nitrifying microorganisms in either soil or water and be a specific pollutant of water.

On a daily basis per animal, the amount of waste does not appear large. But, contemplating the total excreta for a while acre of animals for a full year, one begins to understand the magnitude of the problem of disposal. The 684 tons of dry organic and mineral matter for an acre of 360 animals for a year represents the "ashes" (16) from about 2,800 tons of feed they consumed. These "ashes" are enormously enriched in mineral matter of all kinds, including microelements, potassium, phosphorus, and nitrogen. We have been studying the composition of the soil solution immediately beneath the manure pack.[4/] There were four major cations: Ca, Mg, Na, and K, accounting for at least 99 percent of the cations. Four anions: Cl, PO_4, HCO_3, and SO_4, accounted for about 71 percent, with NO_3 and other anionic unknowns making up the remaining 29 percent. We think that most of the 29 percent consists of polymeric organics, some of which are the colored substances in feedlot waters.

AIR POLLUTION

Figure 1 pictures the three major avenues of nitrogen movement from a feedlot. No data are presently available to quantitate the flux except in the case of runoff. However, I suspect we shall update this model shortly with the second and third looks at the soil nearby and the soil immediately beneath the manure pack. About one-half of this nitrogen is in the urine in the form of urea. Urea quickly hydrolyzes to ammonium carbonate which in turn either decomposes or ionizes to ammonia or ammonium ions, respectively, depending upon the soil and manure conditions. Trapping apparatus, placed in the field by Hutchinson and Viets at Fort Collins, Colorado, was used to capture and measure the volatile nitrogen from feedlots in the vicinity. Their studies show that lake surfaces in the vicinity of large feedyards can absorb large amounts of nitrogen (6). One lake about a quarter of a mile from a large feedlot absorbed about 65 pounds of nitrogen per acre per year. Another lake about 1 mile from the feedlot absorbed only half this much, but it was enough to add 0.6 ppm of soluble nitrogen to the volume of the lake each year (Table 2). This much nitrogen is regarded as sufficient for eutrophication if other factors are favorable. Quantities of nitrogen caught in the traps varied widely during the year, probably subject to major factors of wind direction, precipitation, and season. Obviously, significant nitrogen input into lakes can come from other than runoff of adjacent feedlots. With similar apparatus nitrogen volatilization can be detected from pastures when animals are turned in and when ammonia-bearing fertilizers are applied to crop land. It should be obvious, although not yet demonstrated, that much more nitrogen is adsorbed by soil and vegetation and these probably act as major sinks to cleanse the air (Figure 2).

4/ Paul A. Asmus and Fred A. Norstadt, unpublished data.

Dr. Viets feels that no aspect of pollution from feedyards needs more concentrated research attention than the chemistry of and olfactory response to the volatiles emanating (17). Some people suggest that there are rings of odor around a feedlot, the quality of the smell depending on the distance. Another observation is that a large lot has strong convection currents rising above it on a fairly still day and that the odors aloft greatly exceed those adjacent (Figure 2). Such currents would promote dilution and dispersal except when caught beneath an inversion.

Odor and dust control are closely related but at opposite poles in feedlot management. A dry lot minimizes microbial activity and decomposition processes once the feces and urine have dried. The dry, loose surface, stirred by the hooves of the animals, promotes rapid dehydration of newly added wastes. However, most feedlot owners can get good dust control by sprinkling the lots with permanently-installed sprinkler systems. They prefer a wet lot to a dusty one that may cause penumonia in the animals. Dust control by high urinary input to the lot is given as one of the benefits of high animal densities used in arid regions (17). As you know, water is the _sine qua non_ for life and most assuredly for microbial activity. _A wet lot is a stinking lot_. Reactions and processes in a dry compared to a wet feedyard are as different as dy and night.

RUNOFF

Pollution by runoff is a critical problem in humid areas. State and federal regulations now are forcing operators to install some kind of facility to keep runoff out of streams and lakes, and the idea is sound. The old practices of building lots along creeks or where the lot would be flushed by rains occasionally are now taboo. In areas with more than 20 inches of precipitation, many schemes are being devised (17). Obviously, the runoff problem would be quite different for a lot located in the Salt River or Imperial Valleys than in a humid area like eastern Nebraska. Research data shows that in eastern Nebraska runoff occurs with rains exceeding 0.4 inch on 3- to 9-percent slopes. The runoff amounts to 0.531 times the precipitation minus 0.135 (5). As would be expected, the site conditions of roughness, wetness, and amount of manure cover at the time of rain are some of the factors affecting runoff-precipitation relations.

A comparison of some of the characteristics of runoff in dry and in humid areas is given in the data presented in Table 3. The dry region has an annual precipitation of about 12 inches and the humid area has about 27 inches. The higher precipitation moves off the feedlot larger quantities of total solids, 1.9 percent compared to 6.2 percent, and dissolved solids, 0.5 percent compared to 2.9 percent. Further, the runoff has a higher COD[5/] and from about two to 10 times as much plant nutrients,

5/ The term "COD" means chemical oxygen demand, an empirical value obtained by chemical analysis and is roughly proportional to ten times BOD, biological oxygen demand.

depending on the particular one being measured. Runoff is essentially negligible in areas with 12 inches or less of annual precipitation. It is probably runoff and the possibility of nitrate nitrogen movement into groundwater that has triggered so much concern with cattle feeding operations. In studying runoff and water input to feedyards, sophisticated equipment is used, including automatic samplers for runoff events, temperature and radiation recorders, and weather station equipment.

DEEP PERCOLATION

Much is yet to be learned about the potential pollution of underground water by feedlots. The difficulties of investigation in this area of study are exceeded only by the problems of trying to study the air pollution. Nitrate in groundwaters in Missouri has been attributed to corrals and not to any extent to fertilizer use on farms (10). In Colorado there are numerous instances of abandonment of wells in feedlots or domestic wells nearby, even for livestock use, because of the unsuitability of the water (13). Dr. Stewart and others of the staff at the Nitrogen Laboratory at Fort Collins did extensive core drilling and analyses of soil samples from cultivated and virgin lands as well as feedyards. Nitrogen in the nitrate form on the average per acre in 20 feet of profile is presented in Table 4. Marked differences occur, according to the land management. Interestingly, alfalfa fields showed the least nitrate and movement in the profile. Figure 3 indicates that the nitrate concentration usually declines sharply down the profile. It is interpreted that the absence of nitrate in some profiles and the decline with depth in others indicates denitrification is active under feedlots (14). Samples of water from the top of the water table under different kinds of land use showed <u>no</u> difference in nitrate content due to land use <u>on the average</u>. They <u>averaged</u> about 10 ppm of nitrate nitrogen, which is the U.S. Public Health Service upper limit on drinking water for babies. Thus, we cannot say that feedyards are polluting the water table with nitrate although there were some instances of quite high nitrate in waters from beneath certain corrals. The factors involved are unknown. However, the water under feedlots had an offensive odor and was enriched in ammonium and soluble organic and phosphorus compounds. Some forms of pollution are occurring, but we do not know how far away from the feedlots these pollutants move or the kinds and quantities, nor do we know how long would be required for recovery of the soil and water supplies if the feedlots were to be discontinued (15). Up to now measurements made on the soil solution and samples from the water table produce data that are concentration values. Until we can obtain data that shows the flux or flow of such waters, we are completely in the dark and any conclusions drawn from concentration figures must be tempered with this understanding.

Our knowledge about the chemical and microbial reactions that go on under a feedlot is meager. Nor do we know how to construct a feedlot to avoid groundwater pollution. There are some operators, in the areas where such materials of a natural origin are available, that like to

use sawdust and woodchips for bedding. Study of the soil profile from such a management shows that the quantity of nitrate beneath is much larger than in the case of a lot that has a sealed manure pack (13). In one lot with sawdust and woodchip bedding maximum values were 148 ppm near the soil surface and 87 ppm deep in the profile at about 12 feet, all values expressed on an oven-dry basis. In a lot with only a manure pack, the maximum value was 77 ppm near the surface and about 30 ppm at about 10 feet.

Other experimental techniques obtain data at intervals from the same location in order to observe on a continuing basis the effects of time, season, locations within the feedlot and different depths within the soil profile. For example, recorders attached to floats in wells show a continuous measure of water table height. Waters from other wells are sampled with bailing tubes or suction apparatus. Sometimes dyes are injected into the soil and water samples taken at intervals to study the underground movement. Probably the most dramatic device is the dry well or caisson fabricated of steel and placed in the feedlot and in cultivated fields nearby (4). The walls of the caisson are perforated with ports through which suction cups of porous ceramic obtain soil water samples, diffusion tubes permit gas sampling, thermocouples permit temperature monitoring, tensiometers and psychrometers measure soil water tension, and injected isotopic nitrogen compounds permit tracing of denitrification pathways. Another method devised to examine the kinds and amounts of substances percolating into the soil is the vacuum lysimeter (3). Liquids percolating through the soil contained within the column of the lysimeter are caught in a bottle and removed at intervals for analyses. A suction or partial vacuum is applied to a ceramic plate at the bottom of the soil column in order to cause liquid movement.

Let us examine some of the data obtained from feedyards with the caisson and the vacuum lysimeter. The heavy load of organics on the feedlot has a marked effect on the composition of soil gases.[6/] Note, in Table 5, that, as compared to an alfalfa field soil, the oxygen content declines to values of about one-half to one-fourth as large at the center of the lot and near the feedbunk, respectively. The totals of oxygen and carbon dioxide in the soil are about 19 to 21 percent in alfalfa and at the lot center. Near the bunk where the soil is generally densely trodden and the surface kept moist by the animals' wastes, oxygen contents become very low and the carbon dioxide contents high. Concurrently, methane gas is found within the soil profile as deep as one is able to sample with the caisson installation. It is not clear whether the methane is formed at the deep sampling points or whether it moves there by diffusion from near the manure-soil interface. This question is significant, because if the methane is formed at all depths measured, then it is probable that considerable quantities of organic substances are moving within the soil profile.

6/ Fred A. Norstadt and Lynn K. Porter, unpublished data.

Some recent data of nitrate nitrogen found in soil water samples obtained by means of the caissons at Fort Collins[7/] are shown in Table 6. This is a new feedyard, having been started within the past 4 years. Samples were taken at 6 depths shown in the left-most column. At the groundwater level, little if any difference is shown in the nitrate nitrogen content, and the values of 9.2, 13.9, and 9.8 compare closely with the averages found by coring and analyses of groundwater samples in the work done by Stewart and others in 1966 (13). However, in the top 3 feet of profile, there are striking differences in the concentration of nitrate in the soil solution. The alfalfa soil and feedlot soil from near the feedbunk have values quite comparable. In contrast the feedlot soil from near the lot center has high concentrations of nitrate, although they do decline with depth. It may be significant, even with this young lot, that the groundwater, at the lot center, seems to have a higher nitrate content than that found near the feedbunk or in the alfalfa field. Continued sampling over a long-time period will be needed to observe and evaluate the changes if any (8). One of the problems of such studies is the long time-lag necessary to observe changes in the soil properties.

Similar and analogous data have been obtained by analyses of the leachates[8/] collected in the vacuum lysimeters (Table 7). Again, it is apparent that the animal traffic and some surface moisture within the lot sharply reduces all the constituents regarded as pollutants in groundwater. Lighter animal traffic permits the lot surface to remain open with resultant water percolation and formation of nitrate nitrogen in the soil solution.

Principles being elucidated in cattle feedlot studies should be applicable in some measure to other animal wastes or at least they should be able to indicate some guidelines in studies and trials. The animal producing industry is caught between the demands of environmental quality and a larger supply of animal products (11). Our current technical knowledge is of help but much research is needed. New and unique ideas must evolve in animal feeding, housing, design of lots, management, and waste handling and treatment. Much interdiscipline work is needed by engineers, animal scientists, economists, microbiologists, soil scientists, nutritionists, extension people, and farm managers.

7/ Fred A. Norstadt, Ward B. Clifton, and Lynn K. Porter, unpublished data.

8/ Fred A. Norstadt, H. R. Duke, G. L. Hutchinson, Paul A. Asmus, and Ward B. Clifton, unpublished data.

Table 1. Some constituents of waste of a 1,000-pound bovine on a daily and feeding period basis, and on an annual acre basis with 360 head per acre.

	Per day	140 days	360 head/ac-yr
	lbs.	lbs.	tons
Wet manure & urine	64	8,960	4,200
Dry mineral matter	2.1	294	144
Dry organic matter	8.2	1,148	540
Water	53.7	7,518	30.7 in.
Total nitrogen	0.38	55	24.9
Total phosphorus	0.048	6.7	3.2
Total potassium	0.26	36.4	16.8

Source: Viets (1971).

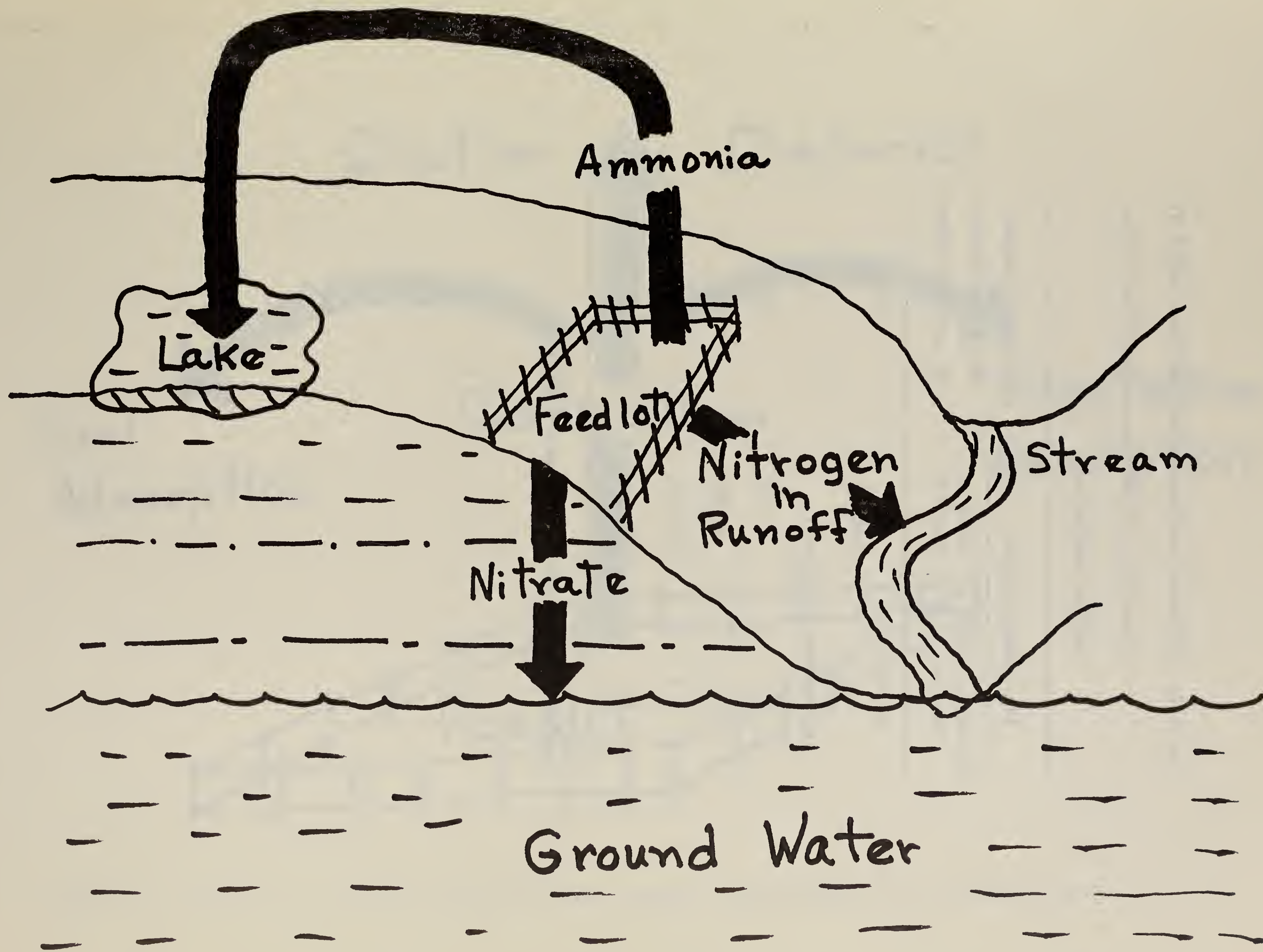

Figure 1.--The major avenues of nitrogen movement from a cattle feedlot.

Table 2. Nitrogen enrichment of surface water by absorption of ammonia volatilized from cattle feedlots.

Site Description		Estimated annual NH_3-N absorption by water surface
Distance from feedlot	Size of feedlot	
miles	no. cattle	lb/A
(no nearby feedlots)		3.5
0.1	700	13
0.3	8,000	14
0.3	80,000	64
1.2	80,000	30

Source: Hutchinson and Viets (1969).

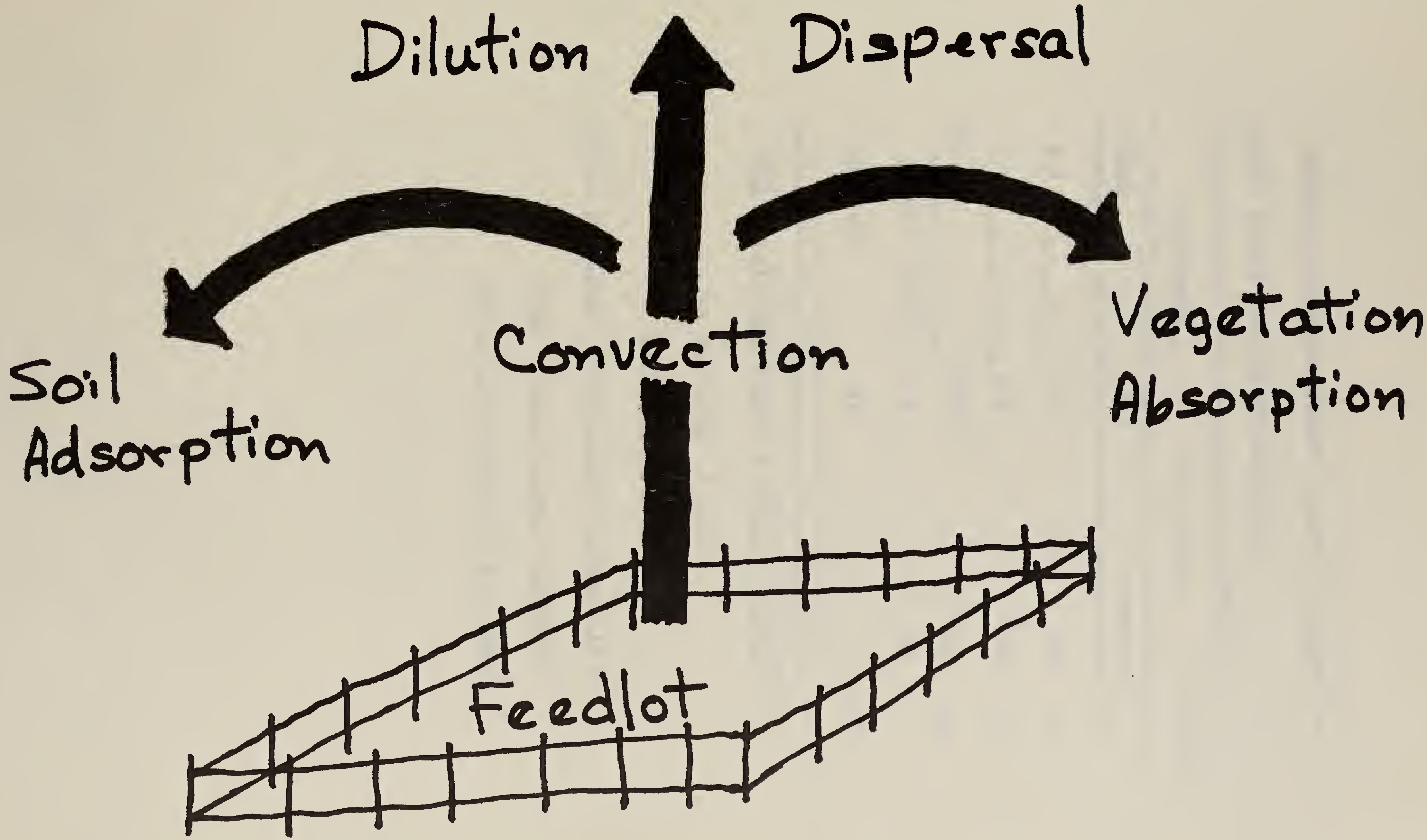

Figure 2. Dispersal of volatile nitrogen from a feedlot and adsorption by soil and plants.

Table 3. Runoff characteristics from feedlots in dry and humid areas.

Analyses	Location	
	Dry	Humid
pH	7.1	7.6
EC[1/]	8.2	4.7
COD[2/]	17,000	25,000
NO_3 [3/]	2.4	24
P	88	205

Sources: Adapted from Viets (1971) and Fred A. Norstadt _et al_., unpublished data.

[1/] Electrical conductivity, mmhos/cm at 25C.

[2/] Chemical oxygen demand, mg/l.

[3/] NO_3 and P as ppm in solution.

Table 4. Average amount of nitrate nitrogen per 20-foot profile.

Land Use	No. Cores	N (lbs/A)
Irrigated Alfalfa	13	79
Native Grassland	17	90
Cultivated Dryland	21	261
Irrigated Fields (except alfalfa)	28	506
Feedlots	47	1436

Source: Stewart *et al.*, ARS 41-134 (1967).

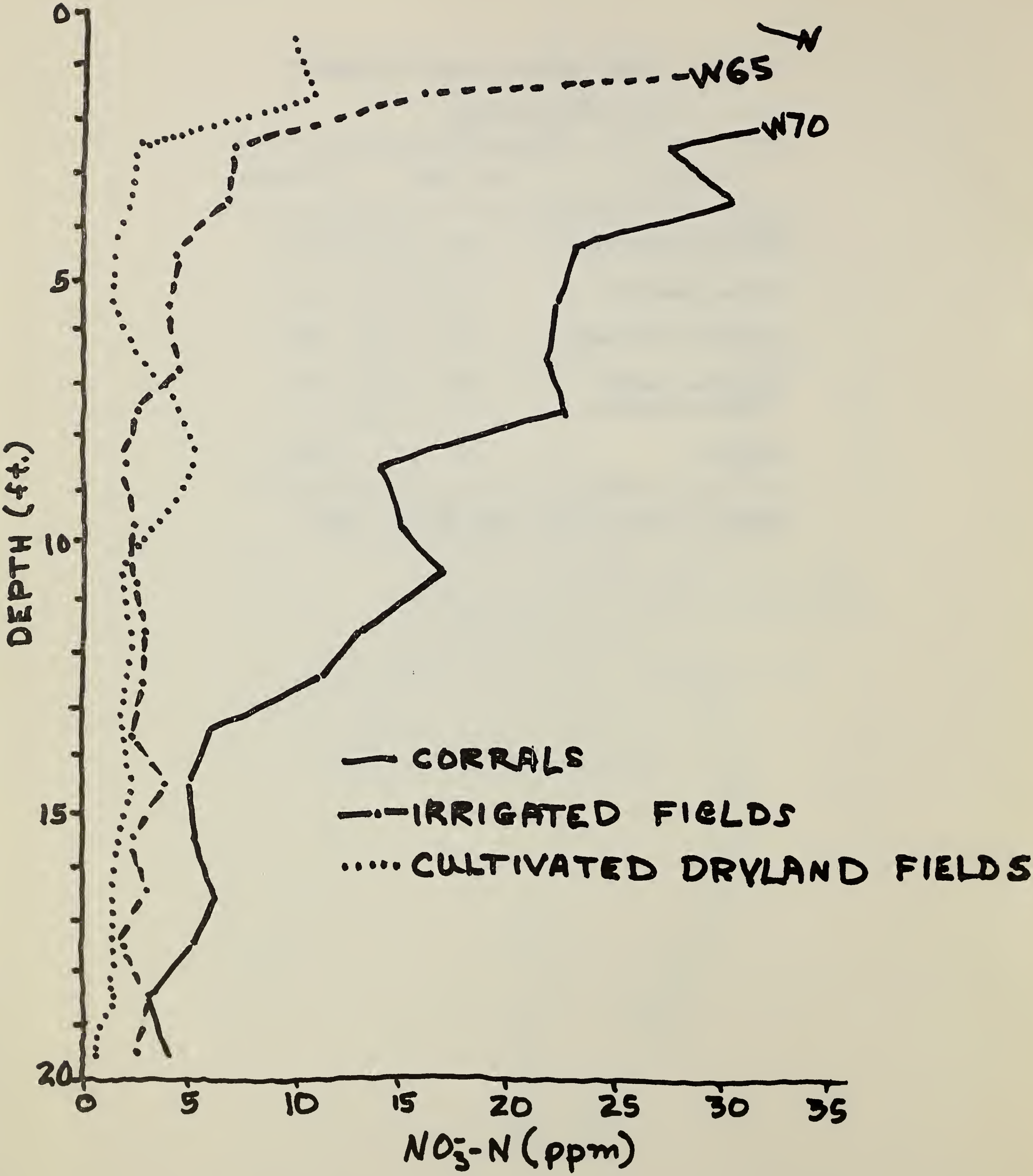

Figure 3. Average nitrate-N distribution with depth of profiles. [Source: Stewart et al., ARS 41-134 (1967)].

Table 5. Composition of soil gases at three-foot depth in cultivated field and feedlot.

Location	Gases				Total
	O_2	CO_2	N_2	CH_4	
	------------- % -------------				
Alfalfa	19.3	1.9	83.4	0.0	104.6
Lot Center	8.4	10.5	80.9	0.0	99.8
Lot Bunk	4.5	23.9	59.6	8.8	96.8

Source: Fred A. Norstadt and Lynn K. Porter, unpublished data.

Table 6. Nitrate nitrogen content of soil solutions obtained from cultivated field and feedlot.

Depth Sampled	Sample Location		
	Alfalfa	Lot Center	Lot Bunk
ft.	ppm		
1/2	43.1	1048	----
2	21.8	180	20.0
3	6.5	84.6	5.1
6	35.3	----	3.7
9	9.0	13.5	5.4
Water Table	9.2	13.9	9.8

Source: Fred A. Norstadt, Ward B. Clifton, and Lynn K. Porter, unpublished data.

Table 7. Analyses of leachates obtained by vacuum lysimeters located within a feedlot.

Analyses	Sample Location: Lot Bunk	Lot Center
pH	7.9	5.7
EC [1/]	2.4	18.8
COD [2/]	359	3223
NO_3 [3/]	2.6	1150
P	0.75	1.02

Sources: Fred A. Norstadt, H. R. Duke, G. L. Hutchinson, Paul A. Asmus, and Ward B. Clifton, unpublished data.

[1/] Electrical conductivity, mmhos/cm at 25C.

[2/] Chemical oxygen demand, mg/l.

[3/] NO_3 and P as ppm in solution.

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FERTILIZERS AND PESTICIDES USE

AS AFFECTING WILDLIFE HABITAT

Donald A. Spencer

Habitat is the key to the production of any wildlife species, be it fish, bird, or mammal. The Soil Conservation Service's business is "a quality environment". Pesticides, as chemical tools, are but one means by which this goal can be achieved.

But what HABITAT? Each species, including man, has differing requirements for cover and food from other living forms that might occupy the same area. A habitat that is a quality environment for one animal species may be completely unsuitable for another. Nature, operating at her very best, never achieved an all-purpose habitat for wildlife, relying rather on plant succession, geology, and the vagaries of climate to create a mosaic of differing habitats. She progressively (and sometimes abruptly) phased one animal out and another in. The antelope is thus a product of the open grasslands, the deer of brush and shrub, and neither can survive under the closed canopy of a forest. Thus the slogan that is currently appearing in conservation journals, "A livable environment for wildlife is a quality environment for man," is overdrawn and often quite erroneous even when applied to species of wildlife.

Habitat must be managed for the benefit of a particular species, or at least a very limited number of species, if maximum production of the desired form is to be achieved. We are indeed fortunate when there is a sufficient overlap in habitat requirements to provide near maximum production of one species (plant or animal) and a bonus in other forms. The Soil Conservation Service has long recognized the existence of bonus values in its land management practices and given both directional and financial assistance in developing these marginal values. The economic necessity of constructing impoundments to furnish both irrigation and livestock water was supplemented by additional financing when these same impoundments were so planned and managed to provide nesting areas for waterfowl. While the principal goal in terracing and contour planting of rolling fields was to prevent the loss of valuable top soil, nevertheless, it serves importantly in correcting the siltation of our streams and lakes that can be so damaging in the fisheries habitat. Again, while the primary goal of the shelterbelt and windbreak was to prevent wind erosion of top soil, to trap snow and reduce moisture loss, these same windbreaks provide invaluable cover for upland game birds and other wildlife, as well as reduce air pollution by dust. Yes, the Soil Conservation Service has long been working toward a quality environment -- one of the most effective programs in our society.

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What then is the present difficulty? Every new problem that arises today is heralded as a crisis and a rush is made to provide corrective legislation. Such precipitous action may not only be unnecessary, but the alternative may pose an even greater threat. Certainly the expense will be several times that of a well-considered action.

Every happening today is treated so negatively that it is difficult to keep from falling into the trap of accepting statements without any attempt to investigate for oneself. Applicable to our situation is the fairy story about Chicken Little who thought the sky was falling, or still another about the emperor who was told he was donning a new invisible wardrobe when actually he had nothing on. Our country is being described as "dying", ravaged by pollution and gross mismanagement. From the platform and from the press we have been forced to sit so close to the stage that the scattered imperfections of the cast, the costuming, and the scenery, detract mightily from our evaluation of the play. Please step back with me for the next few minutes and let us take a look from a better vantage point at our Country, the State of Washington, and the wildlife resources our management of this land over the last half century has achieved.

First, note the new caption, "A Half Century of Conservation." A half century that brought wildlife to a peak of abundance both as to species and number of individuals. Not every species, for the marked changes in habitat we wrought made that impossible. Furthermore, we intentionally suppressed a number of species to reduce competition bearing on our livelihood. It is neither desirable nor are we morally obligated to keep the species status quo. Better than 90 percent of all the species that have existed at one time or another on this earth have already become extinct. There can be little question that man has speeded up the decline of many distinctive animals that were not particularly important to his way of living by the simple expedient of usurping their habitats or over-harvesting them for one reason or another. On the other hand, man has undertaken an aggressive program of breeding to create new types adjusted to the changed habitats and by other management practices is seeking to check the downward trend of endangered species.

Around the turn of the century (1900) game animals in the United States had been severely depleted by over-harvesting and reduction in habitat. Conditions had not improved materially by 1930. Public awareness was increasing and the Migratory Bird Convention (between the United States and Canada) signed in 1916 extended international protection to a very wide range of bird species. Actually it was the sportsmen of the United States who, through purchasing hunting licenses, financed the establishment of game management programs throughout the country. A Federal program in wildlife conservation was mounted under the Bureau of Biological Survey that later became the U.S. Fish and Wildlife Service. This Service is now the third largest landowner in the United States, managing some 29.2 million acres of refuges. The National Parks system can be considered a wildlife refuge as well, adding another 24 million acres. In the U.S. Forest Service some 24 million acres have now been

lands and a total of well over 100 million acres can be shown to have been set aside for the specific benefit of the wildlife resource. Since approximately one-third of the total area of the United States (approx-mately 760 million acres) is Federally owned, it would seem that we are facing no emergency with respect to providing adequately for the wildlife we choose to have about us.

Notwithstanding the extensive areas set aside as "nurseries," most of the game and other wildlife in the United States is produced on private lands that are managed for entirely different purposes. Much of the private sector has been modified from its original habitat makeup. Furthermore, approximately 1-1/2 million acres are withdrawn every year from any support of wildlife by the construction of cities, roads and airports. In addition to the passive effect of land withdrawl, urban activities take a toll of wildlife that fringes each area. For example, the American Automobile Association estimates that cars traveling our roads take a toll of one million animals a day. In 1969, ten thousand white-tailed deer were killed in Pennsylvania by being struck by cars. Even our tall buildings and structures exact a toll. A single TV tower in the Southeast has been killing an average of 3,000 birds a year. Despite this we must have been doing something right for the remaining acreage in crops (300 million acres), pasture and forest are producing more wildlife than at any time in the past. For example, the national harvests of big game; deer, elk, moose, and antelope, have doubled in the last twenty years. When you stop to consider that the pronghorn antelope was an endangered species 40 years ago, this is something of a record. You would hardly expect the black bear to be on the increase in such states as West Virginia, Pennsylvania, and New York -- but it is. Stocks of small game and fur bearers are doing surprisingly well. The beaver is a partic-ularly difficult animal to live with because of its habit of damming small streams that flood roads, and felling trees for food. Nevertheless, we have pelted nearly 2-1/2 million of these fur bearers from the wild in the past 14 years. The populations of the clown of the freshwaterways, the otter, have increased steadily and we have harvested nearly 240,000 of this valuable fur in the last 14 years. Louisiana has turned a South American rodent, the nutria, into a virtual fur bonanza. Starting from an import of 13 nutria in 1937, they harvested some 1-3/4 million pelts from their wild marshes in 1969. The raccoon has increased so markedly that in many eastern states he has become a serious pest.

Upland game birds have done as well. In the early 1930's we had diffi-culty finding enough wild turkeys to start them on the road back -- a truly endangered species. Yet in 1968 we were able to harvest 128,000 wild turkeys from a thriving, expanding population in the wild. Despite an increase in hunting pressure, the native ruffed grouse has provided more shooting, not less. The mourning dove occurs throughout the United States, feeding and nesting in field boarders. They furnish a harvest of over 40 million birds a year. The woodcock about which we were so

concerned at the time of the fire ant programs in the Gulf States, has increased since that time so that we harvested approximately a million birds a year.

It has been demonstrated under controlled laboratory conditions that feeding high levels of DDT or its metabolite DDE in the diet to mallard ducks results in serious impairment of reproduction. That mallard ducks do not receive this degree of exposure in the environment is evidenced, not only by the pesticide monitoring program which found a general picture of only 1.0 ppm DDT complex (wet weight) in mallards, but by the fact that as we recovered from the drought that plagued the breeding area in the Canadian Provinces, the populations have steadily risen. We are looking foreward to the best waterfowl hunting season in the last two decades. Populations were up 18 percent in July over what they had been in 1969, when the harvest of ducks equaled the best year since 1952.

In 1966, the Bureau of Sport Fisheries and Wildlife, in cooperation with some 1,200 ornithologists around the United States, began a new program called "The Breeding Bird Survey." Twenty-five mile routes were mapped out that are covered each June by carefully chosen personnel skilled in bird identification. The observer records each individual and species of bird for three minutes at each of 50 stations along the route. This data is forwarded to the Patuxant Wildlife Research Center and entered into the electronic data processing system. In 1968, on 1174 routes, these observers averaged recording 827 birds in the 2-1/2 hours. In total they recorded 471 species. This program will have to continue for at least five years in order to provide a base for determining whether a particular species is declining or merely reflecting seasonal variables. The first year that ornithologists from Washington participated in the program was 1968. Only 13 routes were covered which is far too few to provide adequate information on the State's breeding bird populations. It is a program worthy of increased attention, for only by such a means can we pinpoint population difficulties before they become critical.

There are other examples, but the foregoing should be sufficient to indicate that the big majority of wildlife species take advantage of the increased production of a limited number of plant species man finds useful for food and fiber. The harvesting and replacement of the forests on a managed basis provides the necessary openings and edge effects that favor wildlife production. By irrigation we have changed the habitats formerly characteristic of our arid lands, and in so doing, adversely affected species adjusted to this rigorous existence. But the wildlife that replaced it out-produces the former occupants many fold, as food supplies are now more abundant.

In many instances we have recognized that we could no longer expect the changed landscape to provide wildlife species it formerly supported. So the professional wildlife manager went looking for a species elsewhere in the world that in past time had become adjusted to just such circumstances. These exotic species, after thorough study and quarantine, have

been introduced under controlled conditions. The task is not as simple as it sounds, for out of some 45 species of upland game birds that have been tried, only three have become well established --the ringnecked pheasants, the chukar partridge, and the Hungarian partridge. Each has filled a vacant niche and we now harvest an estimated 25 million birds a year. Other new and rather exciting gamebirds adapted to special situations have reached the stage of field trial. Big game animals like the Nilgai antelope from India, the Blackburn antelope, Aoudad and Mouflon sheep, and the European wild boar are well enough established to permit hunting. We have developed any number of new strains of fish and thus extended the range of the species. A landlocked strain of the striped bass is causing a flurry of excitement in lakes and impoundments throughout the country. The story of the successful transfer of the coho and chinook salmon to the Great Lakes is well known. The current issue of Michigan Natural Resources reports the catching of a 39 pound chinook salmon -- a record that is expected to fall as the 1970 spawning run reaches its height. Despite the trouble with residues, Lake Michigan has no equal when it comes to fish production, whether you are talking about coho or chinook salmon, rainbow, brown or steelhead trout, or yellow perch.

Let's take a quick glance at the environment here in the State of Washington and the harvests it provides. Thirty percent of the 42,693,760 acres that make up the State's land is Federal Government (yours and my) property. Of these 12,500,000 acres, the Forest Service is the biggest landholder with 9.7 million acres, followed by the National Park Service with 1.1 million acres. The Bureau of Land Management, the Reclamation Service, the Atomic Energy Commission, and the Army each hold roughly a quarter million acres. The U.S. Fish and Wildlife Service has refuges totalling over 100,000 acres, while the Washington State Department of Game, although not necessarily owned in fee title, manages for maximum production approximately one half million acres of game lands. There are 18 million acres of the State devoted to farming, leaving approximately 14 million acres of privately owned forest and rangeland and almost 2 million acres in urban development. The area in inland waters is approximately one million acres, having doubled by reason of impoundments. This aquatic environment was formerly game areas of considerable importance as winter range. Now it remains to be seen if these new water areas can be managed to provide an alternate, but just as valuable, fishery and recreational facility.

The programs of enhancing the wildlife resource have had skillful direction by the State's Department of Game. Washington boasts three species of deer - White-tailed, Mule, and Black-tailed - that over the last 20 years have produced a variable harvest from a low of 25,000 in 1948 to better than 90,000 in 1955 and again in 1968. The snows of the winter of 1968-69 were the worst in a decade and losses in deer are estimated at 150,000 and in elk 10,000. The elk population and harvest however has spiraled steadily upward from around 3,800 in 1948 to 13,100.

Where the State of Washington really shines is in its wealth of game birds. Between waterfowl and upland game birds like quail, pheasants, ruffed grouse, chukar and Hungarian partridge, sage hen, mourning dove, and band-tailed pigeon, hunters harvested almost 3 million birds in 1968.

The harnessing of our rivers to develop electric power and to provide water for irrigation, urban, and industrial uses has brought about disruptive changes in estuarian ecology, and largely eliminated spawning areas necessary for anadromous fish. Since these were largely accomplished changes, the Department of Fisheries, and the Department of Game, have directed their efforts at overcoming these obstacles. Gravid fish, in numbers necessary to supply the number of eggs, are captured in the lower reaches of the river on their return to spawn. The eggs are incubated in hatcheries and the fish reared to one-year (or some designated age/size) then released via the home stream to the Pacific to complete their normal marine cycle. The program is proving excitingly practical and successful. The State hopes to release 2,300,000 pounds of out-migrant salmon this year (1970) and increase this to 3,554,000 pounds annually by 1975.

There are problems in the coastal estuaries like Puget Sound and Willapa Bay, from pollution, dredging, and from conversion of the fresh and salt-water marshes that rim them. Nevertheless, the production of fish and shellfish (as judged by total commercial fishery landings) has not appreciably declined. The total landings of both fish and shellfish are fluctuating from 125 to 175 million pounds of seafood per year (exclusive of sport fishing). The quality of the marine environment can undoubtedly be improved, but it is not a disaster. The harvest of Dungeness crabs has risen from a little over one million pounds in 1935 to approximately 10 million pounds annually in recent years.

This lengthy accounting of various wildlife populations was presented for one purpose only -- to emphasize that with all the pollution, with all the pesticide use, with all the mishandling of land use, the environment is still highly productive and we possess a variety and abundance of wildlife found in few other locations on this planet. We have challenging problems in better use of our resources, but we are not faced with a disaster necessitating precipitous action. I want to emphasize that the people who sound the alarm (as in a fire) are seldom the ones who are called upon to solve the problem. This calls for experienced teams with the best of equipment. A situation where emotion has no place.

Table 1. Big game inventory of the United States[1]

Year	White-tailed deer	Mule deer	Black-tailed deer	Elk	Moose	Antelope	Total harvest
1948	461,500	277,100	48,600	42,000	336	22,600	852,136
1950	581,149	335,040	66,190	54,386	463	36,399	1,073,627
1951	637,617	407,154	57,883	35,562	437	57,387	1,196,040
1952	599,080	420,300	86,586	35,481	719	73,691	1,215,857
1953	547,753	487,135	108,074	47,568	822	70,223	1,261,575
1954	502,209	595,797	108,554	52,396	757	65,152	1,324,865
1955	607,253	648,347	127,135	62,163	955	72,575	1,518,428
1956	680,509	674,697	132,051	63,744	927	60,254	1,612,182
1957	774,534	640,041	99,617	54,572	1,086	52,927	1,622,777
1958	909,299	630,083	113,586	65,167	1,302	49,265	1,768,702
1959	981,865	679,945	146,279	67,766	5,125	56,752	1,937,732
1960	868,218	765,737	159,658	68,697	6,712	62,380	1,931,402
1961	867,764	314,977	158,253	77,905	13,363	75,645	2,007,907
1962	954,766	749,894	154,809	64,221	10,510	79,014	2,013,214
1963	1,129,716	620,515	152,927	74,752	8,933	77,847	2,064,690
1964	1,095,570	685,322	152,835	84,309	10,136	75,534	2,103,706
1965	1,160,691	582,822	132,290	75,428	10,400	61,407	2,023,038
1966	1,273,007	593,558	154,320	84,804	8,605	57,569	2,171,863
1967	1,361,999	599,967	125,440	81,368	7,449	54,925	2,231,148
1968	1,424,445	635,053	154,053	88,447	7,791	54,028	2,363,802
1969	1,361,700	584,620	86,350	89,279	8,560	59,765	2,190,274
Total	18,780,644	12,428,104	2,525,490	1,370,015	105,388	1,275,339	36,484,965

Continued

Table 1 (Continued)

Year	Black bear	Mountain goat	Big horn sheep	Peccary	Wild boar	Barbary sheep	Total harvest
1948	13,900	95	50	5,000	--	--	19,045
1950	14,837	139	61	6,344	216	--	21,597
1951	20,234	131	33	6,851	63	--	27,312
1952	23,282	145	96	6,762	60	150	30,495
1953	22,138	138	177	7,639	283	300	30,675
1954	23,136	134	219	7,661	371	220	31,741
1955	19,834	265	150	7,930	417	--	28,595
1956	19,731	317	170	7,236	410	5	27,869
1957	18,997	689	230	3,561	233	43	23,753
1958	22,576	717	265	4,210	215	48	28,031
1959	21,246	613	260	4,298	300	35	26,752
1960	24,453	1,058	277	5,371	242	20	31,421
1961	20,430	990	320	5,643	182	94	27,659
1962	25,817	1,500	366	5,676	145	46	33,550
1963	21,392	1,568	348	7,268	216	9	30,801
1964	24,187	1,545	304	6,622	740	63	34,399
1965	23,044	1,673	431	6,614	3,131	66	34,959
1966	23,424	1,599	375	6,893	888	69	33,248
1967	23,019	1,471	351	7,018	1,009	131	32,999
1968	22,291	1,452	394	6,700	1,230	93	32,160
1969	18,985	1,471	1,291	7,621	929	40	30,337
Total	446,953	17,710	6,168	132,918	11,280	1,429	616,461

[1] Compiled from Big Game Inventory of the United States, USDI: Bureau of Sport Fisheries and Wildlife.

Table 2. Fur catch in the United States1/

Year	Beaver	Coyote	Fisher	Fox	Fur seal	Marten	Mink
1954-55	183,102	14,516	332	151,263	65,638	7,992	406,486
1955-56	173,553	12,368	323	82,872	122,826	5,763	348,866
1956-57	158,346	21,930	242	146,099	93,618	5,221	399,228
1957-58	188,908	10,395	712	86,192	78,919	4,459	321,900
1958-59	153,022	9,730	500	82,477	58,251	3,982	372,515
1959-60	174,236	6,903	910	138,842	40,616	4,667	355,003
1960-61	204,821	8,553	858	107,172	95,974	6,490	297,216
1961-62	145,030	4,009	1,449	112,660	77,915	5,505	300,495
1962-63	164,125	9,263	2,232	152,072	85,254	9,385	365,936
1963-64	191,245	16,081	2,350	157,039	64,206	7,054	317,048
1964-65	160,401	11,191	1,992	171,663	51,874	10,002	287,269
1965-66	185,461	21,585	2,423	194,886	52,866	8,397	234,261
1966-67	202,168	19,013	2,594	209,211	65,672	9,547	289,262
1967-68	181,826	15,920	1,159 2/	135,629	58,53[illegible]	11,443	181,027
1968-69	168,765	26,828	3,156	215,499	NR	6,540	229,867
Total	2,635,009	208,285	20,073	2,143,576	1,012,161 3/	106,447	4,706,379

Continued

Table 2 (Continued)

Year	Muskrat	Nutria	Opossum	Otter	Raccoon	Skunk & Civet cat	Weasel
1954-55	5,027,871	384,161	257,731	14,902	980,930	129,296	113,951
1955-56	5,449,639	419,350	251,168	12,927	977,777	116,858	96,493
1956-57	5,877,049	543,499	216,711	15,020	1,476,438	131,631	100,170
1957-58	5,608,410	513,586	131,492	16,595	1,189,576	79,857	51,042
1958-59	4,939,782	462,950	80,284	14,323	880,612	58,918	34,984
1959-60	5,077,501	695.209	224,852	16,461	1,146,825	71,718	45,609
1960-61	4,421,338	730,912	186,988	15,353	1,099,699	55,515	24,070
1961-62	4,121,861	917,116	292,628	12,890	1,542,706	61,718	22,062
1962-63	4,613,179	1,362,824	274,628	20,311	1,923,643	47,045	18,121
1963-64	4,994,253	1,309,216	167,353	17,419	1,366,814	45,985	24,625
1964-65	4,305,096	1,572,464	178,391	19,860	1,293,356	34,688	20,551
1965-66	4,678,098	1,262,179	145,753	19,863	1,257,152	32,056	14,925
1966-67	4,273,524	1,312,070	162,981	16,801	1,129,315	33,616	24,729
1967-68	4,157,288	1,120,942	98,514	20,520	887,234	19,459	19,459
1968-69	5,499,790	1,763,445	163,846	15,180	1,188,306	28,498	12,548
Total	73,044,679	14,370,923	2,833,320	248,425	20,329,383	946,858	623,339

Total all 14 species: 123,228,857

1/ Compiled from fur catch in the United States, USDI: Bureau of Sport Fisheries and Wildlife.

2/ 1967-68, Fisher, Maine did not report.

3/ Total does not include fur seal catch for 1968-69.

REDUCING SALT POLLUTION OF STREAMS AND GROUNDWATERS BY IRRIGATION OPERATIONS

C. A. Bower

Drainage waters from irrigated lands flow to groundwater basins or into bodies of surface water either naturally or through man-made conveyances such as tile lines, pipes or ditches. Usually the quality of drainage water is poorer than that of the body of water into which it flows, resulting in a lessening of the quality of the latter.

The effect of drainage water from irrigation operations on the quality of surface water is illustrated by a 30-year study of salt-balance conditions on the Upper Rio Grande (Wilcox and Resch, 1963 and Wilcox, 1967). Figure 1 shows the location of three irrigated areas adjacent to the Upper Rio Grande in New Mexico and Texas. Water is diverted from the river at Percha Dam to irrigate the Rincon Valley (7,000 ha); at Leasburg and Mesilla Dams to irrigate the Mesilla Valley (32,000 ha); and at American and Riverside Dams to irrigate the El Paso Valley (21,000 ha). The drainage water from each irrigated area, consisting largely of water that has leached through the rootzone of crops, returns to the river above the point where the river enters the next downstream irrigated area. The contribution of rainfall over the irrigated areas (about 20 cm/year) to the volume of drainage water is considered to be negligible. Thus, measurements of the flow and ionic contents of the river at Percha, Leasburg, and American Dams and at the El Paso-Hudspeth County line over time permit evaluation of the effects of the drainage waters from each irrigated area on stream quality.

Data on volumes and ionic contents of waters were collected on a monthly basis and have been summarized by years. However, to smooth out yearly fluctuations, the data have been analyzed by 10-year periods. The interrelations between average annual flow, salt load, and salt concentration of the river as a function of increasing area irrigated (proceeding downstream) are shown in Figure 2. Especially noteworthy is the inverse relation between flow and salt concentration. The ratios of loads of individual ions at Percha Diversion Dam to loads at the El Paso-Hudspeth County line (data not presented) show that the return of drainage water from the irrigation operations increases the proportions of Na and Cl and decreases the proportions of Ca, Mg, CO_3, and SO_4 in the stream. Involved in the changes in ionic composition are (1) the removal of fossil Cl salts (mainly NaCl) from the irrigated lands by drainage water, (2) the precipitation of irrigation water Ca, CO_3 + HCO_3 and SO_4 in the soil as $CaCO_3$ and $CaSO_4.2H_2O$, (3) the replacement of soil exchangeable Ca by Na, and (4) a mechanism that immobilizes Mg. The latter could be coprecipitation of $MgCO_3$ with $CaCO_3$ or possibly the reaction of Mg with silicates as suggested by Eaton et al. (1968). Figure 3 shows how the three quality parameters, total salt concentration, sodium-adsorption-ratio (SAR), and

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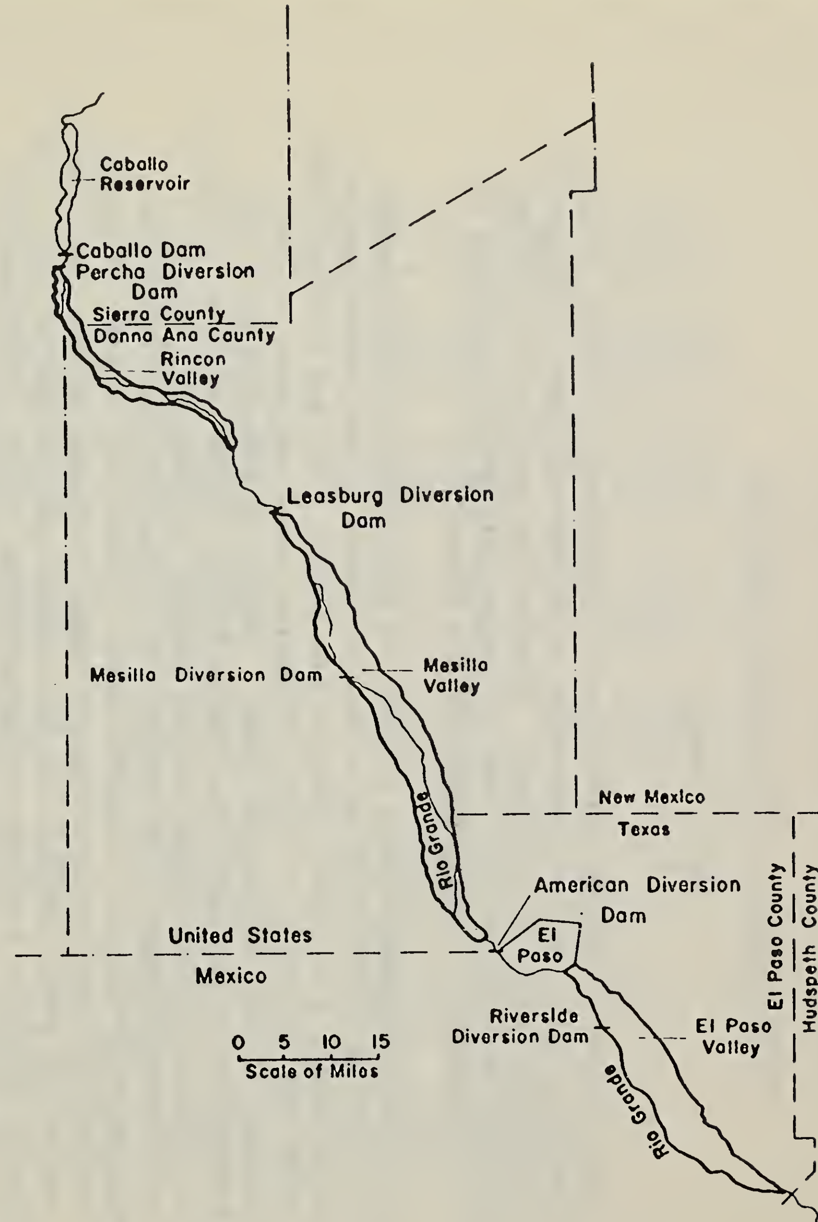

Fig. 1. Map of three irrigated areas adjacent to the Upper Rio Grande.

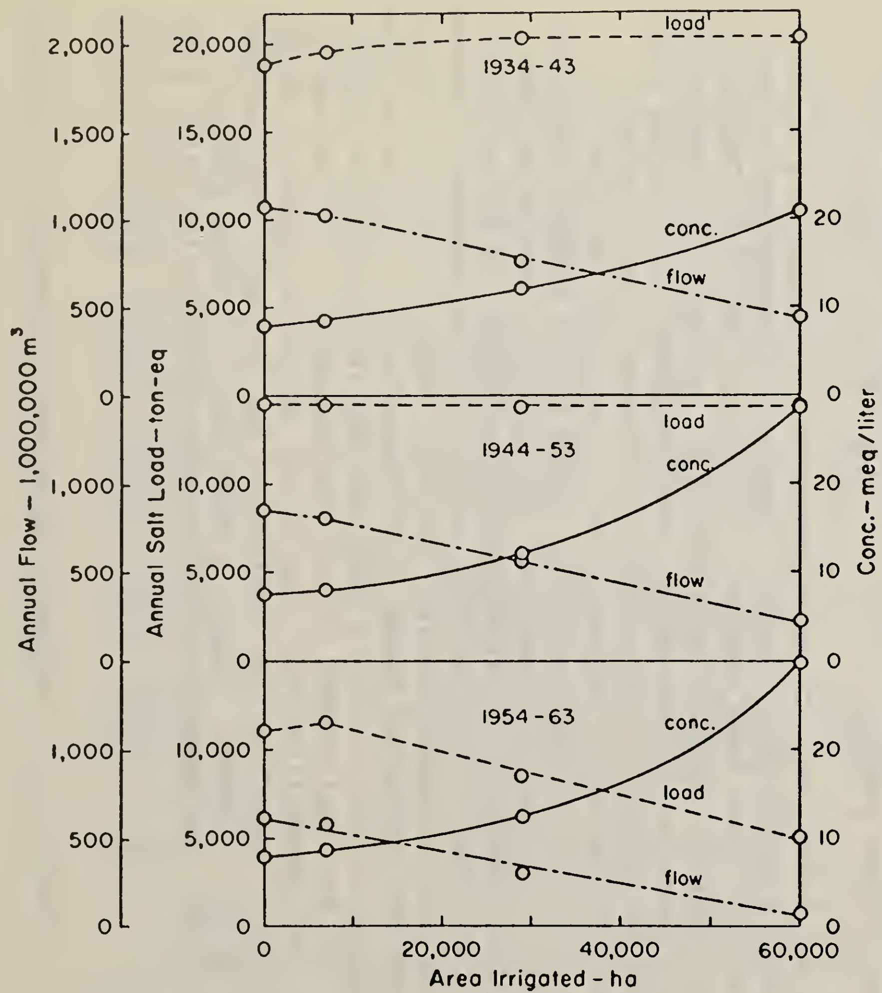

Fig. 2. Average annual flow, salt load, and salt concentration of the Upper Rio Grande for three 10-year periods as influenced by area irrigated.

pH_c^*[1/] change owing to discharge of drainage water to the stream as successive downstream areas are irrigated and the total area irrigated increases. All of the changes indicate degradations in quality for most uses.

The effects of drainage waters on the quality of groundwaters are very complicated and dependent on specific conditions. A typical situation is that in which water is pumped from a groundwater basin to irrigate crops, with the drainage water from the rootzone moving downward but remaining in the basin. If the water pumped and evapotranspired exceeds groundwater recharge, the depth to the groundwater table is always increasing and the drainage water moving slowly downward by unsaturated flow in the vadose zone may never reach the groundwater table; hence, the drainage water does not affect the quality of the pumped water. However, if the amount of groundwater recharge and/or the rate of downward movement of drainage water permits the drainage water and natural groundwater to join, the quality of the latter is, of course, affected. Documented examples of the latter situation are scarce but one appears to have been found.

The Wellton-Mohawk Valley in Arizona comprises approximately the last 50 miles of the valley of the Gila River above the point where it joins the Colorado River near Yuma. The Valley consists of a narrow trough cut in sediments of low permeability that was subsequently filled with sandy and gravelly alluvium to a depth of about 100 feet. An underground granite dike extends across the lower end of the Valley and rises nearly to the surface of the alluvium. From about 1920 until the beginning of importation of Colorado River water in April 1952, the Valley was essentially a closed basin with little inflow or outflow of water because of nearly complete utilization of Gila River water upstream and the presence of the granite dike. Beginning in 1923 and until 1953 a maximum of 4,500 ha of land in the center of the Valley was irrigated by pumping the saline groundwater. The main crops grown were highly salt-tolerant bermuda grass and alfalfa for seed, and irrigation was such that the drainage fraction was large. Analyses of the groundwater pumped from one of the principal irrigation wells are available for four dates during the 20-year period, and in Fig. 4 quality parameters are plotted against time. The data show that quality degraded at only a modest rate until about 1949, after which time degradation was rapid becoming exponential with time.

Because it is the nature of plants to absorb much water but relatively little salt, the leaching of irrigated lands to remove accumulated salts and the resulting production of saline drainage water are unavoidable for successful irrigation agriculture. Drainage waters collected by tile lines and ditches or removed by the pumping of wells can be disposed of in some cases in ways that do not reduce the quality of surface and ground waters. For example, the highly saline drainage water collected in ditches from the San Juan irrigation project in Mexico and formerly discharged to the Lower Rio Grande is now being conveyed directly to the Gulf of Mexico in a separate channel constructed for this purpose. Also, a special channel has been constructed for conveying the highly saline, pumped drainage water from the Wellton-Mohawk irrigation project in southwest Arizona to a point on the Lower Colorado River below the last place where water is taken from the river

1/ The pH_c^* value is an index of the tendency of $CaCO_3$ to precipitate from water; decreasing values indicate increasing sodic hazard.

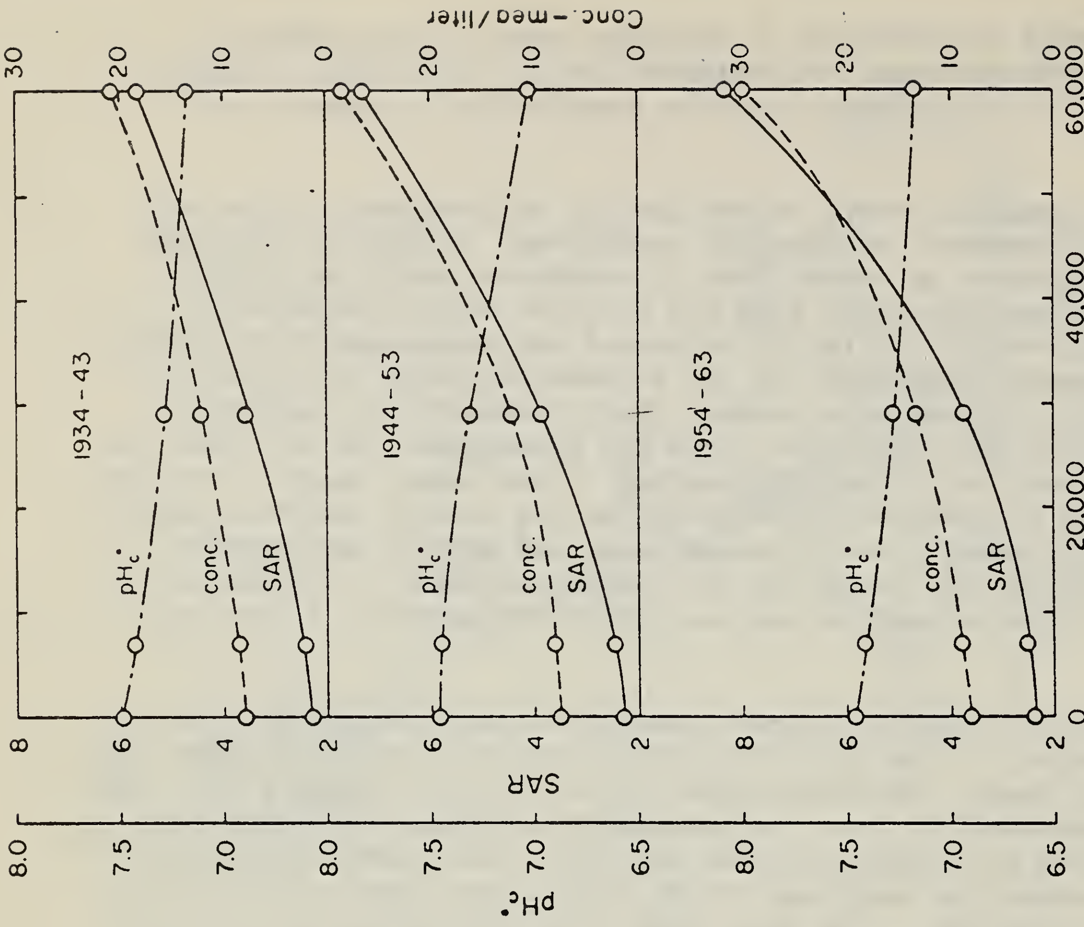

Fig. 3. Average salt concentration, SAR, and pH$_c^*$ values of the Upper Rio Grande for three 10-year periods as influenced by area irrigated.

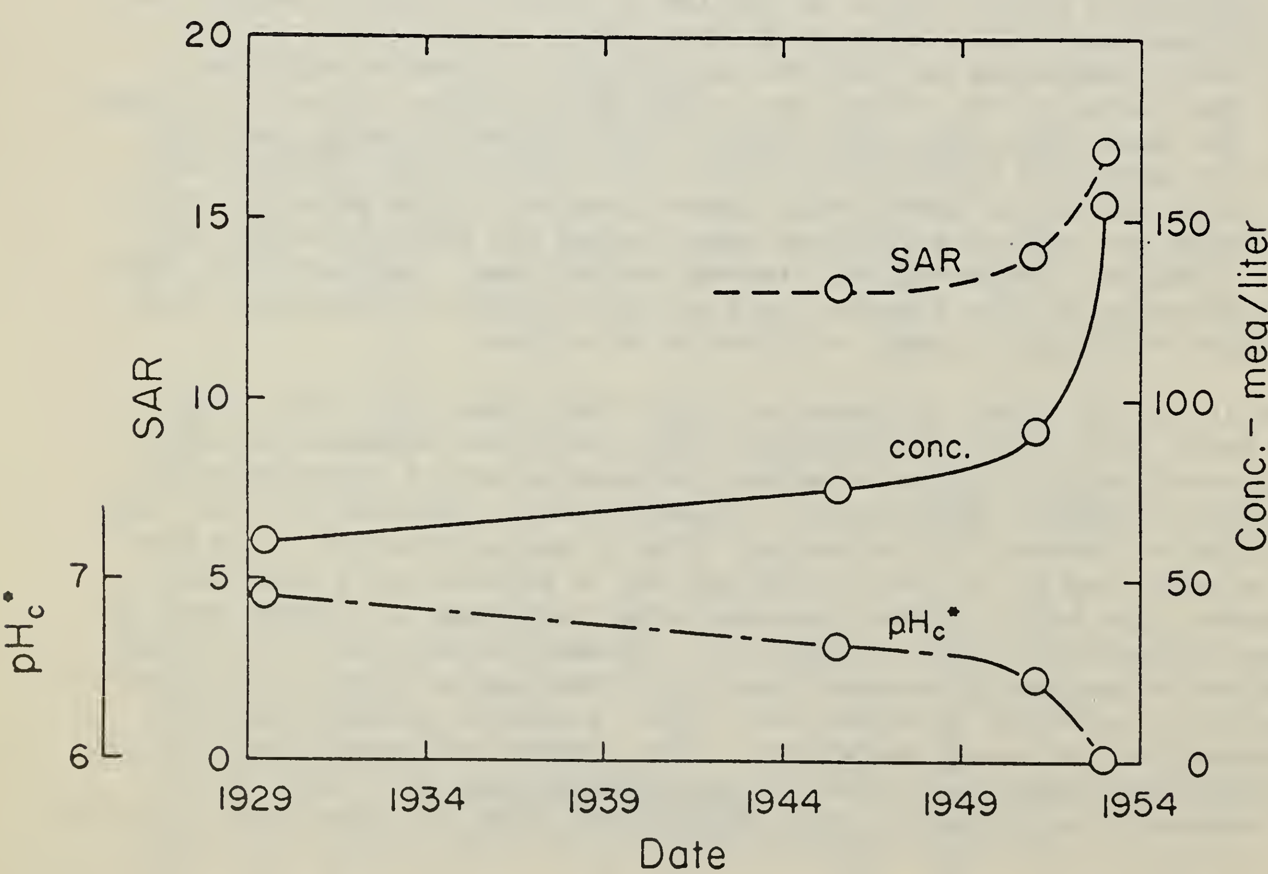

Fig. 4. Salt concentration, SAR, and pH$_c^*$ values of Wellton-Mohawk Valley groundwater as influenced by time.

for use. Conveyance to sumps for evaporation or reclamation by desalination are other possibilities. In most cases, however, disposal of drainage water in a way that does not harm streams and ground waters is not possible nor practical for one, two, or all of three reasons: (1) the cost is prohibitive, (2) the drainage water is not collected nor pumped but moves by underground flow to streams and groundwater basins, and (3) the quality of the drainage water, while impaired, is such that the water still has value for irrigation or other purposes.

Where flow of drainage water to bodies of surface- and groundwater cannot be eliminated for the above or other reasons, pollution of the latter can be reduced by minimizing the amount of salt leaving the rootzone of crops. The amount of salt leaving the rootzone can be lessened in two basic ways: (1) by decreasing evapotranspiration and (2) by removing accumulated salts in the soil solution in the smallest volume of water compatible with preventing crop yield losses from salinity. Reducing evapotranspiration if accompanied by a corresponding reduction in amount of water applied decreases the amount of salt that must be removed from the rootzone in drainage water and can be achieved in a variety of ways including: (1) use of closed water conveyance systems, (2) elimination of non-beneficial vegetation such as weeds and phreatophytes, and (3) growing of crops having lower evapotranspiration requirements as a consequence of the season or length of their growth period.

Removal of excess dissolved salts from the rootzone in the smallest volume of drainage water consistent with no significant salinity damage to crops maximizes the salt concentration of the soil and drainage waters, and hence the precipitation of harmless, slightly soluble salts such as $CaCO_3$ and $CaSO_4 \cdot 2H_2O$ in the soil. It also minimizes the solution of soil minerals and of fossil salt deposits that commonly occur in geologic materials below the rootzone. For example, in a lysimeter experiment involving the growing of alfalfa at four drainage fractions[2/] with six irrigation waters of varying HCO_3 content (Bower et al., 1968), the fraction of applied salt removed in the drainage water at steady-state ranged from 0.55 to 1.25 owing largely to differences in the amounts of $CaCO_3$ that precipitated in the soil. The lower value was obtained at a drainage fraction of 0.1 when 50% of the applied salts was HCO_3 whereas the higher value was obtained at a drainage fraction of 0.4 when only 10% of the applied salt was HCO_3. At equal HCO_3 percentages of the irrigation water, reducing the drainage fraction from 0.4 to 0.1 decreased the fraction of applied salts in the drainage water by about 0.3 with no loss of alfalfa yield. For irrigation waters containing relatively high concentrations of SO_4 and Ca, a similar relation between drainage fraction and fraction of applied salt removed in drainage water should also hold as a consequence of $CaSO_4 \cdot 2H_2O$ precipitation.

Currently, the US Salinity Laboratory has a comprehensive lysimeter experiment underway to determine the minimum drainage fractions required to achieve maximum alfalfa yields with eight representative irrigation waters used in

2/ The drainage fraction is the fraction of applied irrigation water that moves downward through the rootzone.

western US. Data are also being obtained on the fraction of applied salt removed in the drainage water with different drainage fractions. In the meantime, as illustration, the following table gives for several major irrigation water sources estimates of the fraction of applied salt that will be found in the drainage water leaving the rootzone with various drainage fractions. The estimates involve the Ca, HCO_3, and SO_4 concentrations of the irrigation waters, interpolations from the results of the above-mentioned lysimeter experiment (Bower et al., 1968), and the assumption that the solubility of $CaSO_4 \cdot 2H_2O$ in the drainage water will be 30 meq./liter.

Estimated Fraction of Applied Salts in Drainage Water as Influenced by Drainage Fraction.

Irrigation Water Source	Estimated Fraction of Applied Salt in Drainage Water at Indicated Drainage Fraction			
	.1	.2	.3	.4
Colorado R., Yuma, Ariz.	.50	.80	.95	1.05
Rio Grande, El Paso, Tex.	.50	.80	.90	1.00
Gila R., Florence, Ariz.	.75	.85	.95	1.05
Salt R., Stewart Mt. Dam, Ariz.	.75	.85	.95	1.05
Arkansas R., La Junta, Colo.	.25	.55	.85	1.00
Platte R., Aurora, Neb.	.50	.75	.85	.95

The solution of soil minerals and especially of fossil salt deposits owing to excess leaching and deep percolation of drainage water can be a major source of salt pollution in irrigation operations. This source of pollution is being termed "salt pickup from irrigation," and does not include the increase in salt concentration of water resulting from evapotranspiration. The following table compiled from a report by the Colorado River Board of California (1970) indicates, for example, that 40% of the salinity of the Colorado River at Lees Ferry, Arizona results from this source.

Contribution of Various Sources to the Salinity of the Colorado River at Lees Ferry Under Virgin Conditions and at Present

Source	Contribution as a percentage	
	Virgin*	Present*
Diffuse (watersheds)	82	39
Point (saline springs, etc.)	18	9
Salt pickup from irrigation	0	40
Consumptive use by irrigation	0	10
Municipal and industrial	0	2
Reservoir evaporation	0	<1
Transmountain diversions	0	<1

* Virgin salinity = 250 ppm (est.); present salinity = 610 ppm.

Drainage fractions currently achieved in irrigation operations are commonly of the order of 0.5 (Quackenbush, 1968) whereas usually fractions only of the order of 0.1 are needed for salinity control. There are, therefore, substantial opportunities for decreasing salt pollution of streams and groundwater basins through improved water and soil management practices directed toward reduction of the drainage fraction. Aside from economic (water costs vs. labor costs), legal (water allocation methods) and system of water delivery factors (Quackenbush,1968),unusually high and nonuniform soil permeability together with excessive and nonuniform application of irrigation water are the chief causes of excessive drainage fractions. Minimizing the amount of salt leaving the rootzone in drainage water and preventing the pickup of deep-lying fossil salts is, therefore, a matter of improving irrigation efficiency. The leaching of dissolved salts is more efficient and the problems of both excessively high and nonuniform soil permeability are reduced when applied water is made to move through the soil by unsaturated flow. Irrigation by sprinkling permits uniform and controlled rates of water application. By applying water at a rate less than the soil infiltration rate unsaturated flow is achieved. Barriers such as perforated sheet plastic, asphalt films (Erickson et al., 1968) or dispersed clay layers installed at the bottom of rootzones for impeding water movement are also possible means for reducing excessive drainage fractions.

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AGRICULTURE AND AIR POLLUTION

F. Glen Odell

The relationship of agriculture to air pollution is similar to that of industry and the general public. Three basic relationships or roles can be defined: Agriculture as a victim; as a culprit; and as an agent for alleviating or solving air pollution problems.

This paper attempts to provide a brief survey of these three relationships, and outline what are considered to be the major problems that agriculture should be particularly aware of. Given the particular professional interest of the author, the major emphasis will be on agricultural practices that cause or contribute to air pollution.

Agriculture as a Victim

Agriculture as a victim of air pollution was probably one of the first of these relationships to be recognized. At various places throughout the country, damage from oxidants, sulfur dioxide and other air pollutants has been noted and even evaluated economically. In California, for instance, damage to agriculture from air pollution was estimated at 44 million dollars during 1969.(7)* Most of this damage occurred to citrus crops in southern California as a result of photochemical smog. In the Northwest, the most notable example of pollution damage to agriculture has been in The Dalles, where fluoride damage to cherry crops has resulted in law suits running into the millions of dollars. Oxidant damage to tobacco crops in the Southeast has been another problem of some importance.

There is, of course, nothing unique to agriculture in being a victim of air pollution. The national toll, in health costs, cleaning bills, and property damage, is said to be in the billions of dollars. Since most agriculture is carried on in rural areas remote from population/pollution centers, its losses may be relatively smaller than those of other segments of the American society.

Agriculture as a Culprit

Agriculture as a culprit, or as a source of air pollution, has also come to light in recent times. With the increasing awareness of air pollution, agricultural practices are coming under more intense and frequent scrutiny by the public.

* The numbers in brackets refer to references listed at the end of the paper.

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Among the first agricultural pollution sources that might be cited, are problems related to spraying and other chemical applications, pollen, and odors. These are considered peripheral issues with regard to air pollution and will not be discussed at length here. Of somewhat more importance, however (although not generally recognized as a pollution problem), is the generation of dust in dry land farming. Cultivation of soil in dry, windy areas can result not only in a serious soil erosion, but also generates what ought to be considered air pollution. For example, the city of Pendleton, Oregon, primarily an agricultural community, recorded the second highest level of suspended particulate in the state during 1970. The state is not optimistic about achieving national ambient air standards for particulate matter in this area. The problem of wind-blown dust has not been considered a real pollution problem in most communities to date, but there seems little question that in the future, the public will begin to express concern about it. In San Bernardino County, and probably in other southern California areas (where agriculture is at a political disadvantage to the urban community) the first regulations have been enacted regarding generation of dust from agricultural tillage practices.

By far the most significant agricultural air pollution problems, however, are agricultural burning and orchard heating. These practices are common throughout the West Coast states. The major area of concern are orchard heating, field burning, burning of orchard prunings, brush burning for range land improvement and agricultural land clearing.

The most significant of the above is probably field burning of crop residues and stubble. In the Sacramento Valley in California, from 250,000 to 350,000 acres of rice stubble are burned annually. Similar acreages of grass seed fields and cereal grain fields are burned in the Willamette Valley, and somewhat lesser amounts are burned in the eastern Washington-Idaho area and in the lower San Joaquin Valley of California. The reasons for burning the stubble are said to be the control of weeds and pests, and for disposal of excessive amounts of residues. Particularly in the Sacramento and Willamette Valleys, the combination of high water tables, low winter time temperatures, and the potential nitrogen depletion of soils makes the incorporation of 3 to 5 tons of residues per acre undesirable from an agronomic point of view.

In all of these areas, the major environmental effect of field burning is the generation of tons of fine particulate matter (smoke). Open field burning, generating 16 pounds per ton of residue burning, is a prolific source of this contaminant. For example, burning of 500 acres of grass seed fields results in about the same particulate emissions as the 24 hour production of the two kraft pulp mills in the Willamette Valley, or of all the automobiles in the Valley (population of over 1 million).[(3)]

In spite of the enormous emissions, the effects of field burning are primarily degradation of visibility esthetics. The only area where adverse health effects have been widely claimed and to an extent documented is in the Willamette Valley. In this area, the immediate proximity

of the Eugene metropolitan area to about 200,000 acres of grass seed fields has resulted in the frequent inundation of the city by dense field fire smoke. There is, in fact, some evidence that national air quality standards related to health effects may be less than adequate in protecting against short term episodes of extremely high levels of fine particulate matter.

Solutions to field burning problems on the West Coast have thus far relied almost entirely on the concept of smoke management. In the Sacramento Valley, a program of smoke management is operated by local air pollution control districts in accordance with State-issued guidelines, using primarily atmospheric dispersion criteria.[(7)] This program is expected to achieve nominal results in reducing the impact of field burning on air quality.

In the Willamette Valley, smoke management using a dispersion as a primary criterion has been shown to be completely ineffective in protecting the Eugene area from field fire smoke. Under prevailing summertime northerly winds, burning of more than 1500 acres in the south end of the Valley has been shown to result in visibility reduction on a significant number of days.[(3)] After 3 seasons of attempting to use dispersion as a major criterion, the Oregon Department of Environmental Quality began, in 1970, using wind direction and speed as the main determinant of when and how much burning should be allowed. Combined with a detailed system of field registration and acreage quotas on a fire district basis, the wind direction criterion has succeeded in minimizing the effects of field burning on Eugene. However, one of the key elements of the Oregon program, the burning of exceedingly large acreages in the south end of the Valley under infrequent but strong southwesterly winds, results in blowing smoke into the recreational areas of the Cascades. Willamette Valley field fire smoke has on occasion been responsible for visibility reductions in communities east of the Cascades. There is also an unfortunately good probability that incorrect forecasts will occasionally result in large amounts of smoke being blown into Eugene.

Faced with the extreme difficulty of managing field fire smoke in the Willamette Valley, Oregon in 1971 became the first western state to impose an ultimate deadline on the practice of field burning. The legislators, in enacting Senate Bill 38, established a phase-out date of January 1, 1975; established a maximum 50¢/acre permit fee; and directed that 15¢ of the fees be allocated to smoke management and the remainder to development and demonstration of a mobile field incinerator or other alternative practices. The field incinerator project, which began at Oregon State University during 1970 using state General Fund money, is proceeding on a crash basis with a second-generation prototype being tested during the current season. There is some reason for optimism that the grass seed industry, with assistance from government, will succeed in meeting its deadline. Other states have expressed interest and are watching closely events in Oregon to determine whether a solution to the Willamette Valley problem might not be applicable in their own area.

PHASE II - THE INTERRELATIONSHIP OF SOIL, WATER AND POLLUTANTS

BEHAVIOR OF POLLUTANTS IN A SOIL ENVIRONMENT AND IMPORTANT SOIL PROPERTIES IN SOIL POLLUTION

Summary of Remarks by Guy D. Smith

Within the soil, we are primarily concerned with:

plant nutrients and organic wastes,
mineral salts,
disease organisms, and
substances toxic to plants or animals.

These enter the soil:

from the air, in irrigation water, as manure and dead animals, in fertilizer and pesticide applications, from feed lots, septic tanks, sewage lagoons, and salt sinks, from spraying or flooding with sewage or organic wastes, and from sanitary landfills.

Once in the soil, salts can accumulate but the organic materials undergo rapid changes. Some are broken down by chemical reactions, but most are decomposed biologically to carbon dioxide, water, and free nitrogen. The decomposition can be aerobic or anaerobic, depending on the nature of the materials and the nature of the soil. Most can be either aerobic or anaerobic, but conversion of nitrogen to the free state requires anaerobic conditions. Inorganic compounds with positive charges, such as the phosphate ion, and most pesticides are held tightly by the exchange complex, the clay and humus. Some negatively charged ions such as sulfates are, contrary to general belief, also held by many soils though less tightly. Some of our Puerto Rican soils hold over 6 tons per acre of sulfate ions in the upper 4 feet of the soil, or 8 meq/100 gm clay. In Hawaii, where there is a better source of sulfur some soils hold 20 meq/100 g clay and many tons per acre. Nitrate retention is slight.

The soil properties that are important to the use of soil as a sink for organic wastes are:

(1) saturated and unsaturated hydraulic conductivities,

(2) depth to water table and to rock,

(3) nature and amounts of clay and organic matter

(4) soil temperature,

(5) soil moisture regime.

Dr. Guy D. Smith, Director, Soil Survey Investigations, Soil Conservation Service, Washington, D. C.

Saturated hydraulic conductivity is important to sprinkling or flooding the soil to dispose of wastes and to the functioning of sewage lagoons.

Unsaturated hydraulic conductivity is important to the functioning of septic tanks.

A water table at some depth is essential to removal of nitrates from the soil.

Soil temperatures in the south are generally favorable for rapid decomposition of organic wastes.

Clay and organic matter are important in removing the phosphates.

Clays with low cation exchange capacities seem, in general, to retain more sulfates.

Nitrogen deserves special attention. It is added by manure and organic wastes and by fertilizers. It is removed from the soil by plants, by denitrification, and by leaching into ground water.

Denitrification requires anaerobic conditions, favored by ground water and organic sources of energy. Process is very rapid.

Leaching is favored by a continuously very moist soil, such as the mountains of Washington, or irrigated soils, or absence of soil structure. If the soil has blocky or prismatic structure and is below field capacity, nitrates are not easily leached because they are drawn into the blocks or prisms by capillary forces when the soil rewets and are protected from leaching to some extent.

THE RELATIONSHIP BETWEEN LAND USES AND POLLUTION SOURCES

Lloyd E. Partain

In the assignment of this title, your program committee emphasized "Agricultural Use: Urban and Suburban." It would seem that with such a broad title no further adjustment of scope would be sought on the part of the speaker to which the topic was assigned. The topic for the paper appeared to me to be broad enough, indeed, but the topic for the workshop did not seem to encompass all that I felt might be appropriate for this presentation. The term "Pollution Abatement" struck me as being a bit restrictive. So did "Pollution Sources." In discussion with Mr. Kortan about such restrictions, he encouraged me to expand my thoughts beyond pollution to include relationships of land use to other environmental concerns. That will be my purpose.

It is most fitting that this topic be discussed at this workshop. Its importance is attested to by our Administrator in his Advisory MGT-5, dated February 19, 1971, regarding 1972 Goals. In that document setting forth the national goals for the Soil Conservation Service for the 1972 fiscal year, he cited as point No. 1:

> Identify the significant changes in land use that should receive priority attention of the Service and the District Governing Bodies, and undertake appropriate action to guide these changes.

That advisory stressed implementation of the Service's long-range plan and closed with the following which I believe is important to keep in mind in our workshop discussions:

> Under-Secretary Campbell emphasized what USDA hopes to do in the areas covered by the Secretary. Pressures on our natural resource base will be far greater than in the past, he said. A sound, workable land use policy is urgently needed. Also during this decade we must (1) identify and reserve ample space for agriculture and forestry, (2) make provision in suburbs and near cities for open space and access for recreation, beauty and wildlife, and for air and water management and an escape from noise pollution, and (3) improve the management of our water resources, emphasizing how water management is a part of good land use, and how sediment and other pollutants it carries damage natural resources and the environment and impairs production, industrial and service facilities. He spelled out goals and actions required for a systematic, comprehensive, overall approach to environmental management and improvement on a nationwide basis. In the process we will be helping to achieve rural development and overcoming environmental degradation.

Lloyd E. Partain, Assistant to the Administrator for Environmental Development, Soil Conservation Service, Washington, D. C.

In other places in the Administrator's advisory on 1972 Goals, these pertinent points were also stressed:

> . . . environmental progress also depends on improving the social environment through better health.
>
> The 1970's challenge SCS with new demands. Added skills and a greater awareness of the special conservation needs of people in rural and urban areas are required.

Added skills and greater awareness! I assume that is what this workshop is about, with focus on pollution and related environmental problems.

Now, I shall attempt to discuss land use--agricultural, urban and rural--in relationship to the foregoing general backdrop.

Much of your workshop agenda is directed at acquiring "added skills" in this important and growing activity directed at pollution and degradation. That is as it should be. Perhaps I should give more attention in what I have to say to "greater awareness."

The first important point, perhaps, deals with law. Federal statutues now prohibit, to growing degrees, the disposal of unwanted wastes in our waters and water courses, into the air, or dumping them into the ocean. Many states have enacted stringent laws in this respect. Most states have adopted water and air quality standards. Certain municipalities have imposed strict regulations governing pollution of air and water. Few laws and regulations exist, so far, restricting disposal of wastes in the soil, and where else is there to put them when the only known receptacles for wastes are the air, the water, or the soil?

A long-existent practice among many people has been that anything that is unwanted and must be disposed of can be buried in the ground and forgotten. This now becomes an accelerated activity--a challenge to those of us who are supposed to know about soil, the land, its capabilities, limitations, and capacities. Our experience in dealing with land use from the standpoint of agricultural and forest production and related erosion control and conservation measures is no longer enough. We must examine other land uses.

As others have said at this workshop, the earth is a great filter, a cleansing medium. But, there are limitations and a wide range of controlling conditions prevailing in the practicable safety zone that must be determined.

Our colleagues in the research phase of resource management and use seek better answers as to how much we can depend on the soil as a safe waste disposal sink. The nation sorely needs those better answers. It will not be enough to know the capacities and limitations of soil types and soil groupings for assimilating various types of wastes. The proximity of the source of wastes to potential disposal areas may be equally important.

Since most of the harmful or unwanted wastes originate with the activities of man and tend to become problems in areas with substantial numbers of people, the land site factor may be the limiting one. No doubt the time has arrived when in many areas of the country sheer space (landspace) must be considered a basic resource in overall conservation, development and wise use. In connection with disposal and treatment of most wastes originating in agricultural pursuits--from livestock and crop production, processing of agricultural commodities, etc.--the range of site selection may be wide indeed compared to using the land for disposal of urban and industrial wastes. But we in agriculture, including the land owners and operators with whom we work, are being asked to provide not only the land but a great part of the know-how to make this feasible. It is certain that agricultural land must be used more and more for urban waste disposal.

Suitability of land (or soils) for this purpose is only a part of the problem. The economics of the matter is another; and in some areas the part that is most difficult to solve. As has been cited in this workshop, there is, or can be, beneficial uses made of many wastes when judiciously applied to the land. Oftentimes the economic, cost-return equation will govern the procedure, however.

This causes one to look at both sides of the coin. Those whose problems of disposing of wastes--municipal authorities, industries, processors and others--stand to benefit also. An equitable system of cost-sharing must be determined. Standards and guides that meet the varying conditions are highly essential. Much is already known about urban wastes that can be used beneficially on cropland, pastures or woodland, or at least with little or no harmful effects. Examples are municipal garbage, sewage effluents and sludge, and wastes from food processing. But the economics applying to this kind of land use have not been perfected, it seems to me.

The disposal of industrial wastes poses more difficult problems, perhaps. At least such wastes are so diverse in their composition and other characteristics that we dare not generalize as to the possibilities for incorporating them into soil continually used for agricultural production. This does not mean, however, that we who are charged with conservation and wise use of soil and water resources can sidestep the problem.

If the wastes cannot be incorporated into the soil and utilized in normal agricultural production operations, we may have to allocate land areas to this use exclusively. There are fears among many that such competition for land space endangers our future food production capability in this country.

Can we afford to use our land for such waste disposal purposes? Let's look at some facts bearing on plausible answers to that question. In recent times about one and one-half million acres have been dropping out of cropland use each year. The Economic Research Service analyses tell us that in a recent five-year period 54 million acres were abandoned or shifted to noncrop uses. But during the same period for every two acres that went out one acre of new cropland was developed--principally through

drainage and irrigation. On balance, then, the annual reduction came to about 1.4 million acres. The drain is not as bad as it might seem. Moreover, much of the new land is more productive than that abandoned.

The trend in overall increase in production per acre and the increase in total production on fewer and fewer acres have been well documented here at this workshop and elsewhere. This is common knowledge among agricultural workers but not among the general public. A part of the reason for such a phenomenon, of course, is soil and water conservation and other improved land use practices. When viewed in the light of our known capacity to produce food and fiber and the associated problem of surpluses, I think we must say that we do have enough land space to allocate some of it to waste disposal as the primary use.

When we do so, we create a host of problems, some of them new. Perhaps the most difficult one is local in character--which acres? General national figures can't be too helpful in this regard. The soil survey and its interpretations as to use limitations are a good beginning, but only a basic beginning. People involvement, planning, relative costs of alternatives, decision making, land rights, laws, regulations, health, aesthetics and a host of social issues must be a part of the problem solving, else more problems may be created than are solved. Associated with it all are transportation of the waste material, its character (including its pre-treatment and conditioning), the potential secondary uses of land compatible with waste disposal systems, the multiple use concept, and reclamation of the disturbed and used areas making them as useful and pleasing to the eye as possible.

I am told by our soils people and sanitary engineers that the best sanitary landfill sites, for example, may be on the best agricultural land in the community. It is only natural that most farmers, along with some other people, will resist such changed land use. Regardless of the availability of productive agricultural land nationally, the matter becomes one of economic adjustment locally.

Also, what neighbor wants to have a sanitary landfill, a sewage lagoon, other waste disposal structures, or even fields where waste products are applied in slurry irrigation nearby his home. Even though we who have or will acquire competence in the soil, water and resource manipulation aspects of such systems are generally charged with supplying facts and appropriate interpretations for use of the decision makers, our involvement does not stop there in many instances. We are looked upon as experts--as we should be--and our dealing with people and their problems often throws upon us a new challenge. Engineers must have some basic knowledge of biology or rely on a biologist. The planner must know a great deal about law, politics, and government. I only use these two examples to indicate that dealing with some of the emerging problems of land use in relation to pollution abatement and enhancement of the environment requires a greater degree of interdisciplinary teamwork than any other challenge that has come our way. We should look upon it as a real

opportunity, however, and I hope that workshops such as this leave us better prepared and encouraged to tackle the job that is ours in this regard.

Of course, we do not have all the answers; we never will have. For example, there are those among us who deplore the sanitary landfill method of disposing of solid wastes as wasteful in itself, not only of the land space required but of the products being disposed of. We think of a waste as merely being a resource out of place, something that should be recycled or re-used. Recycling and re-use are a noble goal, indeed. We are making some progress in this respect; but the mechanics, the economics, the chemistry, and other limiting factors must await further research before great headway can be made toward a closed cycle for most waste products. In the meantime the problem of disposal increases. We must move ahead, with less than a perfect system perhaps, relying on the best of our abilities and the research and techniques that are available to us. A job that is going to be done anyway will be done better by our having been of assistance in doing it.

My remarks up to this point have centered on pollution abatement and related environmental problems in areas of or near heavy concentrations of people. But this nation's environmental problems are not limited to such areas. The wise open spaces have serious degradation problems related to resource use. Many, but not all, such problems are here in the west. Time will permit reference to only a few of those in this paper.

We hear a great deal about the need for open space land programs. This interest has become a claimant on lands near cities. This need is highlighted in messages from the President, in proposed National Land Use Policy legislation, in the new "outreach" program of the Department of Housing and Urban Development, in a new thrust under the Land and Water Conservation Fund administered by Bureau of Outdoor Recreation and in some of USDA's land retirement efforts. In my opinion, the expertise of the Soil Conservation Service can be much better utilized than it is now in the selection and conservation treatment of such lands. Some good experience with watershed projects and RC&D project measures in such areas should encourage us to expand our efforts in this phase of land use.

Recreational development and use of land and water resources should have a major consideration here. In the west and to some degree elsewhere, our expertise is sorely needed in resource conservation and protection of fragile park, forest, range and shore lands. Those engaged in recreation planning and development, plant materials work, range and watershed activities are providing assistance in this regard. Suffice it to say, we need to do more.

If you have been involved in reviewing environmental impact statements referred to SCS, as I have recently, you know of our increasing involvement in the land use problems connected with highway and airport development. At the current rate highways and airports outside urban areas are

taking some 160,000 acres of new land each year. The amount of land required for these purposes is of minor interest to SCS, it seems to me. What land, siting, routing and the effects on adjacent lands are of greater importance to us in our professed specialties. Our relationship with highway and airport authorities at both the national and state levels is quite good. The need for our services increases daily. Erosion and sediment control, including roadside stabilization, especially on secondary and tertiary roads, remains a real problem in many areas. Perhaps we need new authority or clarification of existing authority, along with adequate finding, to make the headway needed in this land use problem.

Indicators such as sales of boats, vacation travel vehicles, camping gear, snowmobiles and trail bikes, reveal the increased use of land in outdoor recreation. An estimated two million families now own cabins, cottages and second homes. More than 30 million acres are in national and state parks, and more land space is being allocated to such use each year. Needless to say, the pressure of use on such areas creates pollution and other environmental problems to be reckoned with. In addition more than 50,000 private landowners are engaged in offering recreation as a use of some or all of their lands. From the sociological standpoint of environmental needs of our people, this is all to the good. But it does create problems in land use, pollution abatement and multiple use planning. It may be said that recreational and wildlife and wilderness uses do not seriously compete with agriculture for land space. Up to now most of the land taken for such uses has terrain or drainage features making it unsuited or unadaptable to agriculture. This is not true in all instances. Some competition occurs when wetlands having a particular ecology and serving as habitat for waterfowl and other wildlife are drained for agricultural use. Our interest in this broad recreation--wild lands category goes beyond agriculture. Our contribution as resource scientists and technicians can be substantial here.

We must not overlook water development as a growing user of land space and as a vast influence on improvement of the environment. Reservoirs claim about 420,000 new acres each year. No doubt the rate of change to this use will rise as population and living standards increase. Regardless of some current criticism of water development programs among the active environmentalists, our efforts to make water resource development a true enhancement of man's environment must move forward at a more rapid pace. Of course, we must make adjustments wherever possible to carry out full multipurpose objectives.

Our listing of land use problems in relation to the environment would be incomplete if we did not include surface-mined lands. This use takes a sizable bite--150,000 acres-- and leaves ugly scars on the landscape each year. Moreover abandoned, stripmined lands exceed two million acres. Progress, including recent enactment of effective state laws governing restoration of newly mined lands, is being made. Many of the soil and water conservation techniques of SCS, involving soil surveys, engineering and vegetative practices, are needed in minimizing or eliminating this environmental problem.

THE RELATION OF ANIMAL WASTES TO LAND USE MANAGEMENT

Fred A. Norstadt

It can be well-demonstrated that confession is good for the soul. Penetrating and astute minds attest so in their writings. For example (5), Benjamin Franklin is reputed to have penned: "I have indeed now and then a little compunction in reflecting that I spend time so idly; but another reflection comes to relieve me, whispering, 'You know that the soul is immortal; why then should you be such a niggard of a little time when you have a whole eternity before you?' So, being easily convinced, and, like other reasonable creatures, satisfied with a small reason, when it is in favor of doing what I have a mind to, I shuffle the cards again and begin another game."

I feel no compunction in confessing that I am biased in respect to manure, animal wastes in the new vernacular. I confess that I find the study of the corral or feedlot fascinating to the point that odor, flies, 5-buckle overshoes, smells on hands that resist soap, scouring cleanser, and mild acid, the noisy, pushing, inquisitive cattle--all recede into the background. What these materials do in the soil is even more intriguing. I hauled about 30 to 40 tons of a mixture of cattle manure and sawdust and wood chips onto my yard which is composed of the primeval material that contractors leave about a new house and blasphemously call "soil." During the past year I have raked, observed insects and other arthropods, watched slime molds grow and decline, seen mushrooms fruit and disappear, noted soil aggregation and structure improve, and hoed weeds, apparently well nourished. I believe it would have required a strong constitution and iron will to have specialized in chicken or hog manure. Fortuitously, my experience has been with cattle.

I doubt that my reactions are a case of fluke behavior. I make my confession to impress upon your minds that not only are our attitudes and habits plastic, but also to surmount our problems, we must intentionally, skillfully, and adroitly deal with the problems and the people who control them. As I stated in the previous presentation, it is logical to think that basic concepts concerning one manure apply to another.

WHAT SHALL WE DO WITH THE LOTS?

Some of the old lot configurations and management systems will have to be changed. Lots that border on streams or those placed on slopes so as to flush with rains or snow melt are obvious sources of surface water pollution. Surprisingly, yet perfectly logical, long-standing water in a lot is not indicative of percolation and water-table pollution. If the soil profile is open and hydraulic transmission high, there will be no long-standing water in the lot. To the casual observer, these relations are not apparent, and he must be instructed.

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Runoff from winter thaws and rainfall events transports considerable solids (2). A control facility to intercept runoff must include means of handling the solids as well as the liquids. Settleable solids should be removed from runoff prior to reaching a liquid detention pond in order to extend the liquid storage capacity and to prevent long-lasting anaerobic conditions in the pond which cause foul odors. In an experimental situation, but nevertheless on a commercial lot 120 feet wide and 300 feet long, runoff from the lot was collected by a metal trough set flush into the soil just below the downslope fence of the lot. The lot had a 6 percent slope and southern exposure (7). In controlling runoff, one of the most important considerations is to prevent excess drainage. Where drainage from higher ground can flow across a lot, the pollution potential is increased and runoff control facilities receive extra burden. A diversion terrace constructed immediately above the lot will divert excess water away from the area (3). In the experimental installation being described, the runoff passed through a settling basin or organic solids trap equipped with screens of hardware cloth at right angles to stream flow to assist in retaining solids. The settling basin was essentially a level terrace. The solids that collected were quite unobnoxious and odor-free. The material can be stockpiled until land is ready to receive it, or it can be returned to the lot surface. The liquid fraction, salty and dark in color, came to rest in a collection pond. Evaporation can dispose of some of the volume, but most of it is probably best placed on cropland located away from streams to reduce pollution. Application has to be to the soil, since direct folliar application causes burning and killing of vegetation. Insufficient long-term experiments have been made to properly study crop-land disposal to learn about the effects on vegetation and the soil. It is possible that the salty character of the detention-pond liquids could be moderated to permit sprinkler application to crops if suitably diluted with irrigation water. Percolation from the pond is minimized by sealing the bottom. It appears that considerable denitrification of nitrates takes place in the pond during their residence therein, but the liquids have not been studied.

The design and sizing of interception facilities, solid traps, and liquid detention ponds will depend on the area served and method of disposal. The management of the liquid is particularly important, especially in high rainfall areas, since research indicates climatic conditions influence quantities of runoff to a greater degree than the physical attributes of slope and animal density (2). Historic climatic information can be used to determine detention pond volume or probable precipitation accumulations over a period of time. Rainfall during an individual storm can result in as much as 70 percent runoff while accumulative rainfalls result in approximately 40 percent runoff over a period of weeks. Minimum storage requirements would be set by using the larger of the two calculations coupled with decisions on the management scheme for disposal of the detention pond liquids.

In reality, any of the systems to control feedlot runoff are modifications of long-established and tested structures to control surface waters and

include diversion terraces, level terraces, conducting structures, and ponds and basins. Personnel of the Soil Conservation Service have particular skills and techniques that should be readily applicable to solving the problems of runoff from cattle feedlots. Although mixing of solids and liquids in a detention pond is not recommended, a basin at the foot of a slope could be an effective intercept for runoff as a "first aid" measure until a different and better system were devised. Earthen structures within a lot receive considerable animal traffic and must be constantly maintained. If the debris basin is located within the lot proper, the solids that accumulate there can easily be moved upslope to restore the storage capacity, but the system would need more routine maintenance than interception structures outside the lot. An additional problem could arise from animals wading in the basin which would have a tendency to keep materials in suspension and make difficult a neat separation of solids and liquids.

Individual plans for each feedlot are unique, since physical conditions such as size, soil types, topography, rainfall, and other items will vary for the geographic location (3). Cardinal considerations include locating a feedlot away from streams, near or on the top of slope, away from towns (and preferably protected from urban encroachment by zoning), and in a direction so that prevailing winds carry away and dispel odors without carrying them into an urban area. Once a waste disposal system has been installed and functioning, several management items require attention in order for the system to function properly and continue to have a long life(3). Important management items include removal of solids from the debris basin, repair of earthen banks when erosion or rodents damage them, scraping of excess manure into mounds for animals to rest upon, and avoiding the scraping of manure down to the soil surface. A manure layer protects the soil from water erosion since the manure mulch acts as a sponge to hold runoff to a minimum. If lots are scraped completely clean, runoff will increase which results in a greater management problem with the liquid. A manure pack on the lot will also help to reduce the dangers of ground water contamination.

Arid regions can have a better opportunity to isolate themselves and the runoff problem is minimal even with very large lots. Up to the present, technology largely has concentrated on moving feed and removing manure. The lots themselves have not changed much. There is some experimentation (2) that may lead to better designs. The use of microbes and arthropods to help degrade manure are incidental and uncontrolled. They just happen. We have not looked at many salt-resistant species of plants to consume runoff waters.

It may be that sophisticated runoff monitoring equipment will be needed to insure compliance with regulations. Perhaps wells to regularly monitor the water table will be required or cores taken to observe changes in the soil over time in order to monitor commercial feedyards.

As data begins to accumulate from present experiments, we refine our hypotheses and update our models. Some of our earlier ideas surely will change. For example, it is difficult to conceive of any appreciable nitrate nitrogen movement in a section of rather dry soil profile. So dry that liquid samples cannot be obtained, and water films are extracted from tensiometer apparatus so that it no longer functions. Could it be that ammonia is diffusing from near the manure-soil interface downward across the dry zone? Upon reaching soil, moist enough for nitrification, the ammonia is used by the nitrifying microrganisms and converted to nitrate (see Figure 1)? Experimental evidence from cultivated soils indicates adsorption of ammonia in soil is too strong to permit such gaseous diffusion, but we do not know about the entirely different conditions at the manure-soil interface within the feedlot profile. Nitrification processes can take place at soil water contents as low as those near the wilting point, although at reduced rate. Once the nitrogen is in the nitrate state, it becomes highly mobile by diffusion, even at high soil suctions (4). Such a relation of dry and wet portions in a profile can develop in a feedlot soil of medium texture with a water table at about 15 feet. If so, then some water table contamination does not necessarily involve percolation.

A well-sealed, flat, level lot behaves a bit like a table top upon which water is spilled or which is jiggled with marbles or stones on its surface. Eventually, under influence of animal traffic, the materials move off its edges onto the nearby soil that is not sealed (see Figure 2). Dust and fine manure are deposited on unsealed soil. Soil cores taken outside but near a feedlot generally show high concentrations of nitrate (2, 7). This phenomenon may result in considerable entry of nitrate into the soil. It is also possible that the nitrate in the soil outside the lot moved there by diffusion, even in soils of low water content. Once outside the confines of the feedlot, the soil nitrate would not be subject to as severe denitrification reactions as directly beneath the lot, and its life in the soil would be extended considerably.

Up to now little has been done to the soil profile. Natural processes in the soil often seem adequate to dispose of most of the pollutants that move downward. Research information also indicates pollution of the water table is minimal. Observations of feedlots with sawdust and woodchip bedding indicate excellent odor control. Owners and operators like to use those materials. Animal health appears to be improved as compared to a lot with only packed manure covering the soil. Feeders prefer a natural soil base over paved lots for several obvious reasons. Suppose we were to incorporate these ideas into a scheme to modify the soil profile as shown in Figure 3? Perhaps we can capitalize on the principles we believe we understand! The loose surface of manure, woodchips and sawdust has a tendency to remain open and more porous, or we could intentionally stir it. The plentiful oxygen content of the surface promotes the aerobic microbial processes which do not produce obnoxious odors. More ammonium nitrogen is nitrified, which, as it moves downward, is consumed in denitrification reactions with any moving organic matter. There is somewhat more water entry into the soil to

fill the pores of the finer-textured layer beneath the top sand layer. The silty-clay layer intensifies denitrification because of its finer pores and saturated (or nearly so) condition that restricts oxygen entry. A fine-textured layer of soil resting upon a coarse-textured layer would fill with water and generate a perched water table. Any liquids finally percolating into the gravel or coarse sand could be intercepted and returned to the lot surface for recycling. The impervious barrier on which the drains are placed would prevent movement of pollutants to the water table. In the laboratory, we have produced 50 percent denitrification with only a 4-inch-long soil column receiving an urea input equivalent to a stocking rate of one animal per 75 square feet. The above described system or a similar one is surely to be tried soon in an experiment by someone. Right now, we have the knowledge and expertise to make the needed calculations to determine the necessary soil textural fractions and sizing of the other parameters to design an artificial soil profile configuration to control both odor and percolation of pollutants.

INNOVATIVE ANIMAL WASTE USES AND TREATMENTS

I have to forego touching on this subject. There are many interesting and stimulating ideas being explored, not the least of which is the concept of recycling of the waste of one animal by feeding that waste as part of the ration of another (6). Not too many years ago, the recycling of animal waste was common in the practice of running swine with cattle in the feedlot. The swine recovered a large quantity of the grain passing through the cattle as well as being supplied considerable benefit from substances produced by the flora and fauna of the herbivore's gut. This practice, like that of returning the manure to the soil as normal procedure, has been sacrificed in the specialization of animal finishing. However, I believe that the general consensus of the experts is that return to the land is the logical deposition of animal wastes, at least for some time to come.

FATE OF MANURES IN OUR SOILS

Analytical Data

There is much analytical data describing the plant nutrient contents of animal manures. Table 1 data indicates that there are some but not great variations among the animals shown. It is recognized in practice that sheep manure has considerably more available nitrogen. All of the trace elements are present in manures. The data given in Table 2 is from an analysis of a mixture of cow, horse, swine, sheep, and poultry manures. A slurry of manure removed from the surface of a feedlot, containing 85 percent water, was analyzed (9). An application of 20 ton per acre would supply 116 lb. of N, 72 lb. of P_2O_5, and 124 lb of K_2O. Such analytical data does not indicate the availability to plants as that can be assessed only by actual tests with growing plants. Such tests indicate approximately 50 to 60 percent of the nitrogen will be mineralized during the first year in the soil.

Storage Decomposition

If we wish to limit the organic matter and eliminate much of the nitrogen before field disposal, then composting in storage, in the lot, or some other facility can promote the reduction. For example, a growth chamber study (9) simulating temperatures and day length and using feces and urine at a stocking rate of 50 square feet per animal, was found to cause loss of 90 percent of the nitrogen in 21 days and 50 percent of the volatile solids were lost in 120 days. With poultry manure, dropping-pit storage caused loss of 77 percent of the nitrogen and 55 percent of the organic matter in 140 days.

In Soil Decomposition

It has been known for a long time that manure decomposition, as with most other organic amendments, proceeds rapidly in soil. Manure contains 10 to 15 percent of lignin, which is fairly resistant, but even it eventually is decomposed. All other organic constituents go very rapidly. About three-fourths of the organic matter is lost in the first year. Nitrogen loss is reduced and the fertilizer value is promoted by turning the manure under (see Table 3). Mineralization by the soil microorganisms and utilization by growing crops are promoted by tilling. Of the remaining materials, humus-like substances become part of the humus-complex of the soil. The ultimate accumulation of organics will be only a very small fraction of the total organic quantity applied to the soil. Western soils, in general, should be improved with additional organic matter and minor elements, although the additional salt would hardly be welcome.

According to the statistics of one large feeder, about an acre of land produces enough corn silage, alfalfa, and corn (assuming a yield of 100-bushel-per-acre) to fatten 1.62 animals. On the average, 1.62 animals produce about a ton of dry waste in the feeding period. If an acre of cropland can safely utilize 10 tons of dry manure per year, then only about one-tenth as much land is needed for productive waste disposal as is needed for growing the feed. Anyone who has lived on a livestock-grain farm knows that there is never enough manure for use on all the fields.

Cautions

Mineralization of excessive amounts of animal wastes, even within the limits of good crop response, may result in leaching nitrate and salts into groundwater or it may result in runoff carrying nitrogen and phosphorus. Enough manure could be applied to result in accumulation of organic and inorganic constituents in concentrations toxic to plants (9).

A recent study in California was made of a small dairy region with a high concentration of animals (1). The authors studied soil nitrates and salts in the unsaturated soil below the soil root zone and above the

ground water level. Prevailing practice used a cow-to-land-acre ratio of 10:1, which was a manure application of about 20 to 45 tons per acre per year. The researchers concluded that the animal-to-land ration should be reduced to about 3 animals per acre to reduce nitrate nitrogen to 10 ppm or less in the soil solution.

There is no doubt that more studies are needed to assess the potential to contribute nitrate nitrogen to ground water and salts to the soil. Further, the complete management picture needs to enter, since there are probably significant crop-soil interactions that affect the results of manure rates. The use of one percent NaCl in rations in arid regions poses an additional hazard.

NORMAL AND RIGHT FINAL DEPOSITION

It seems to me that the social climate is right or soon will be to recondition our attitudes toward animal wastes. Time was when experimenters were busy showing that mineral fertilizers could replace manure, and this influence and other factors surely did succeed. I recently talked with nursery field managers about their present attitude toward manure. One informed me that experimentalists at the state agricultural college did many trials for them with manure and commercial mineral fertilizers. The researchers demonstrated that manure was of no advantage. It is no wonder then that manure was promptly dropped when weed seed became a problem along with introduction of a very troublesome weed. Other factors cited were costs of freight, handling, and spreading. Another nursery manager praised the improvement in soil physical conditions but lamented the weed seed and lack of manure within close hauling distance.

Today, we are teaching and learning that our resources are not inexhaustable. Here, in these wastes, we have a material with which we have to do something. In many areas it cannot be ignored. Then, at least for awhile, let us return it to the land regardless of the fertilizer value! Cities are inundated with solid wastes and sewage sludges with no easy deposition alternative. The animal husbandryman has the solution for his wastes, arguments of economics notwithstanding. I am confident economic solutions can be devised for impetus.

Why not turn our experiments and information services to the task of changing attitudes and philosophy toward animal wastes? We could be amazed at what demand might be generated for "steer" manure, deodorized and pelleted chicken manure or what have you devised? Where are our Yankee ingenuity and entrepreneurs? Let us find out from the former and potential users of animal wastes what it is that prevents utilization today. Then we can set about to promote their demand.

There has been considerable change and development in soil fertility knowledge and concepts since the time when animal manures were first left in the lot to wash away or rot. The manures of today are richer in nutrients than formerly, with modern emphasis on animal nutrition

and rations. Cow manure was once regarded as quite low in phosphorus; not so today. I have seen a manure compensate in a sulfur-deficient soil. Experimenters are beginning to take another look. Our past literature is replete with countless experiments of rates, crops, and soils. Some updating is needed, but as a first approximation, any harm would be minimal with the old rates.

There are those who would go to the extreme in loading our soil with animal wastes. The soil is an open system with inputs of plant and animal remains, our wastes, precipitation, irrigation, fertilizers, and so on. Outgo consists of field crops, meadows, gardens, tree crops, leachates, and gases to the atmosphere. It is a most marvelous arrangement. We must not in our enthusiasm turn our soils into disposal dumps with animal wastes (and forgive me for changing the subject) or with sewage sludges. A soil has a certain capacity, usually unknown without careful and long study, to dispose of wastes that it receives. Those knowledgable stewards of our soils who are in contact and work with public officials and others have a special responsibility and trust. Whatever is done, however we employ our soils in coping with our pollution, our actions surely must be cautious, educated, deliberate. What changes we provoke may come rather slowly, and their reversal likely will be slow and costly. Thus, there are no pat answers. It does seem that a careful examination of the route we traveled to arrive in this condition would be useful in finding our way out.

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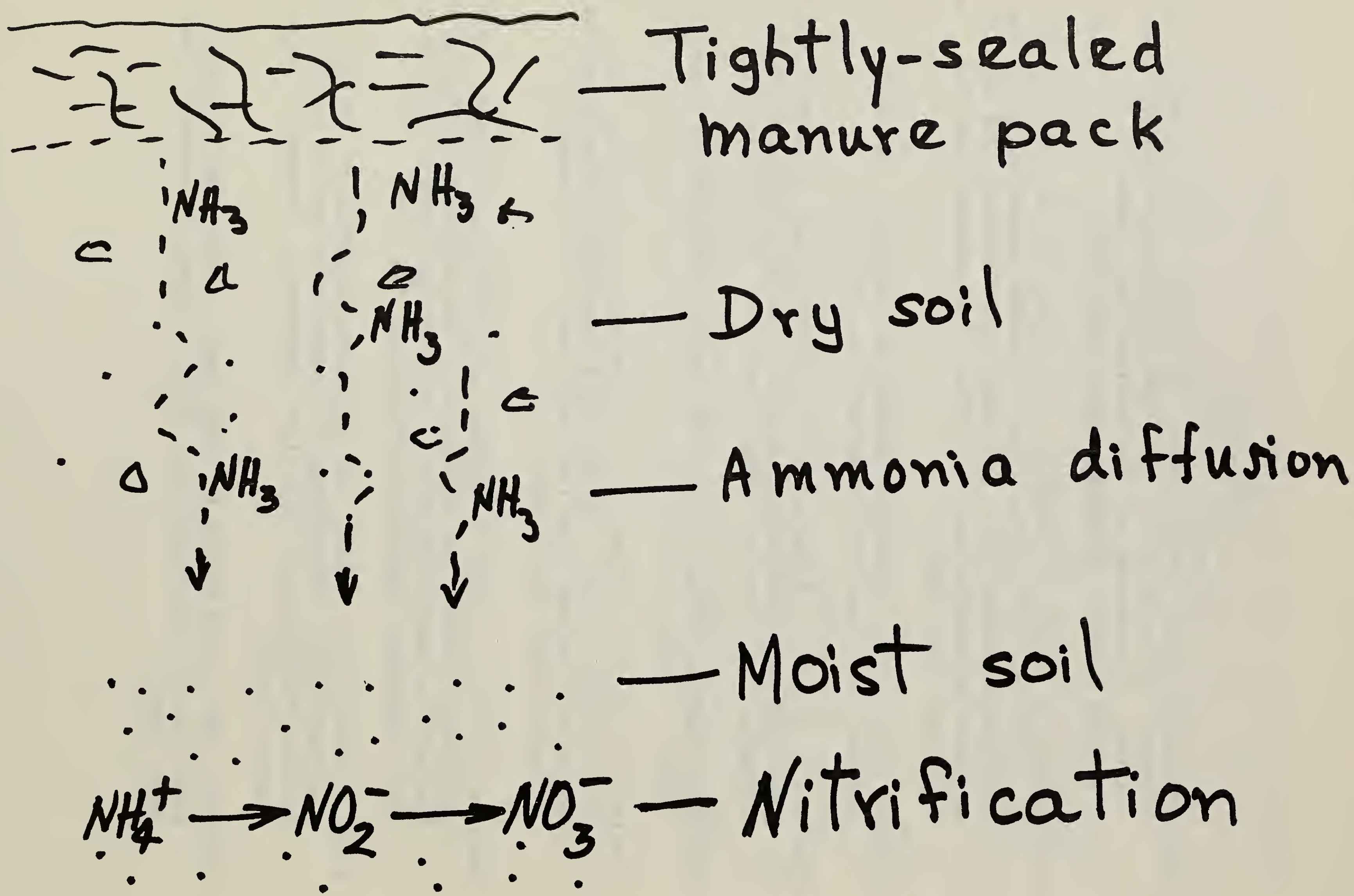

Figure 1. Hypothesized ammonium nitrogen movement and nitrification and nitrate diffusion in the upper soil profile of a feedlot.

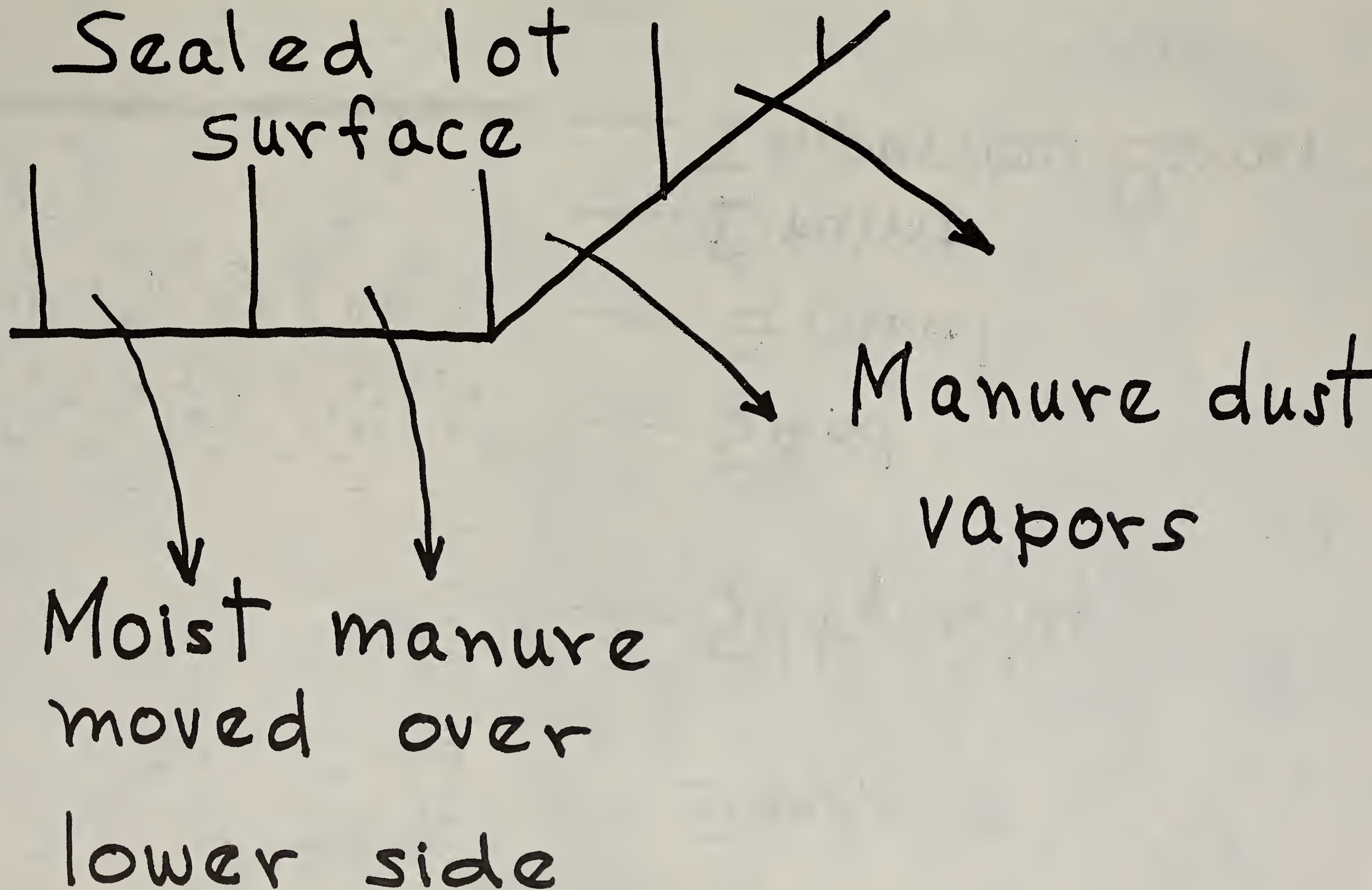

Figure 2. Movement of manure materials to unsealed and permeable soil outside of a level cattle feedlot.

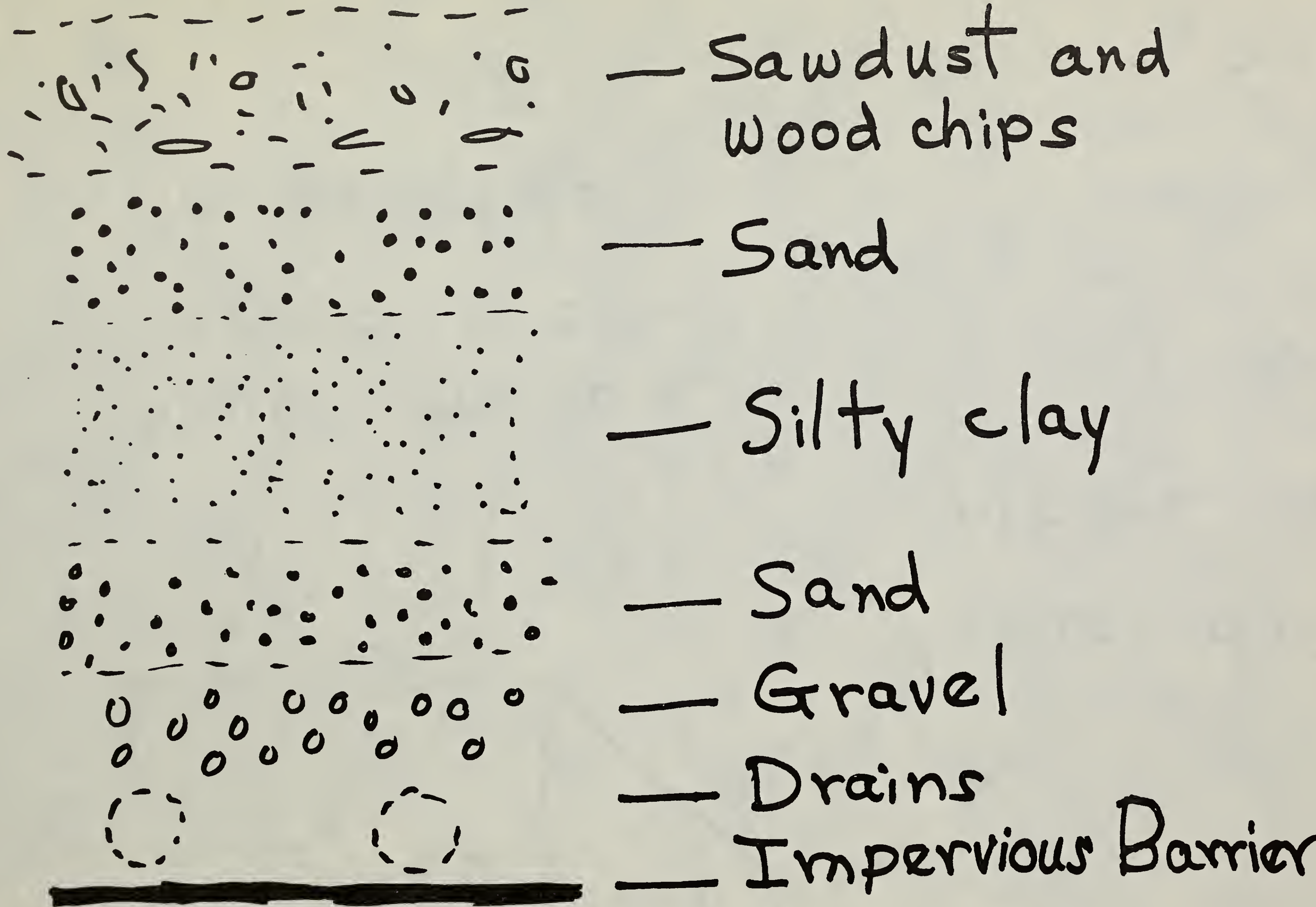

Figure 3. Proposed soil profile modification of a feedlot to control unpleasant odors and prevent percolation from reaching the water table.

Table 1. Some of the constituent chemical elements found in manures from cattle, hogs, and sheep.

Element	Cattle	Hogs	Sheep
	------------- lb/ton	--------------	
N	14.0	10.0	28.0
P	4.0	2.8	4.2
K	9.0	7.6	20.0
S	1.7	2.7	1.8
Fe	0.08	0.56	0.32

Source: Table 17.2 in Agricultural Practices and Water Quality. The Iowa State University Press, Ames, Iowa, 1970.

Table 2. Trace element composition of a mixture of cow, horse, swine, sheep and poultry manures.

Trace Element	ppm
Boron	20.2
Manganese	201.1
Cobalt	1.04
Copper	15.6
Zinc	96.2
Molybdenum	2.06

Source: Table 17.3 in Agricultural Practices and Water Quality, The Iowa State University Press, Ames, Iowa, 1970.

Table 3. The effect of delay of incorporation of manure into soil on its relative fertilizer value.

Plowing Time	Relative value-crop	
	Oats	Potatoes
	-------- % -----------	
Immediately	100	100
After 6 hours	79	86
After 24 hours	73	70
After 4 days	57	44

Source: Table 17.9 in Agricultural Practices and Water Quality, The Iowa State University Press, Ames, Iowa, 1970.

THE EFFECT OF AGRICULTURAL WATER MANAGEMENT ON MINERAL SALTS AND TOXIC SUBSTANCES AS POLLUTANTS

D. L. Carter

Introduction

The quantities of mineral salts and toxic substances entering rivers, streams and lakes from irrigation practices depend upon the quantity of return flow from irrigation, and the proportions of that flow from surface runoff and subsurface drainage. Water passing across the surface of the land picks up little salt or toxic materials except those associated with sediment picked up by erosion processes. In contrast, water passing through the soil reacts chemically with minerals and dissolves soluble salts where contact is made. Subsurface water generally contains very low concentrations of toxic substances.

The quantity of pesticides and soluble salts picked up by water as it passes across the surface of the ground depends upon the amount of erosion that occurs. Thus, if erosion processes are controlled, the quantities of mineral salts and toxic substances in surface return flows will be minimal.

Twin Falls Canal Company Tract Study

A study was recently completed on a 203,000-acre irrigation tract developed by the Twin Falls Canal Company (Figure 1). The tract has been irrigated for about 65 years with water diverted from the Snake River in southern Idaho. Water is allocated to farmers at the rate of approximately 0.5 cfs continuously for each 40 acres of land. Water is in the canal system from about April 1 to November 15 each year. Canal flows in the early spring and late fall are considerably lower than during the peak irrigation season of June, July and August because some crops do not require early spring and late fall irrigation.

Soils of the study area are wind deposited, calcareous, silt loams, ranging from 0 to 50 feet deep. A caliche and silica cemented hardpan is found beginning about 12 to 18 inches below the soil surface over most of the area. The soils are underlain by fractured basalt to depths of several hundred feet. Water infiltration rates are fairly high and most crops are irrigated by small furrows.

The most important crops, and the acreage of each during the study year, are alfalfa, dry beans, sugarbeets, small grain, corn and pasture (Table 1). The row crops are normally seeded in April and May and normally the last crop harvested is sugarbeets, which is generally in October. Mean annual precipitation for the area is approximately 8.5 inches.

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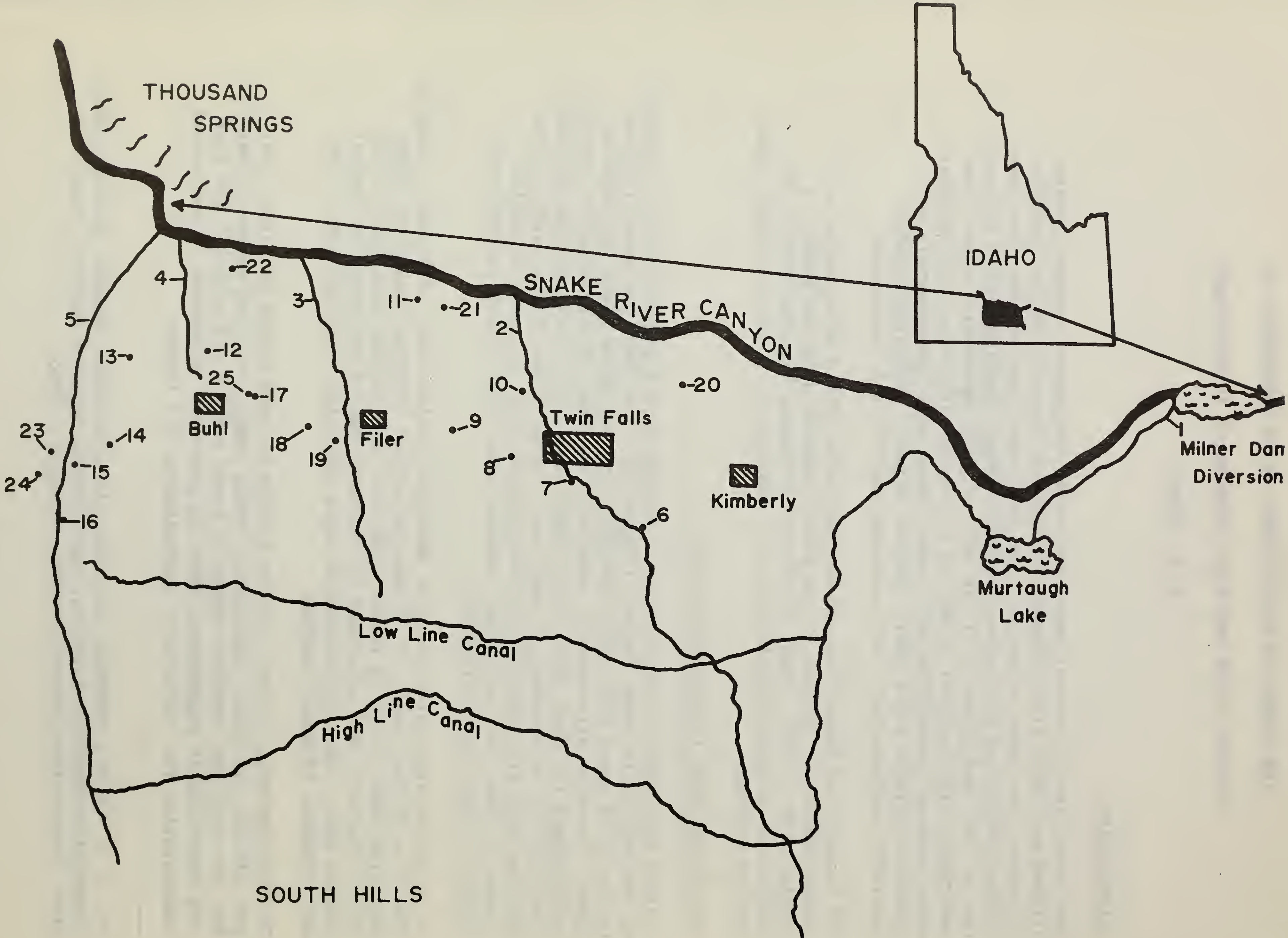

Figure 1. The 203,000-acre study area illustrating sampling sites and important features.

TABLE 1. Crops grown on the Twin Falls Canal Co. tract and the estimated evapotranspiration (ET) for each for the year October 1, 1968 through September 30, 1969.

Crop	Acres	ET Entire Year	ET Crop Season
		----Inches----	
Alfalfa	37,811	41.4	39.1
Dry beans	35,333	24.8	19.6
Spring grain	24,302	23.0	18.9
Sugarbeets	21,069	32.6	30.0
Corn	15,765	27.8	23.5
Fall grain	8,100	24.1	19.6
Potatoes	3,997	29.9	26.3
Peas	2,130	24.3	20.3
Towns, canals, etc.*	20,000	42.2	40.1
Nonirrigated area	12,570	7.7	----
TOTAL	202,700	----	----
Weighted mean	----	31.0	----

*ET considered the same as for irrigated pasture.

High water tables appeared in localized areas throughout the tract soon after irrigation was initiated in 1905. To alleviate this problem, the Canal Company excavated horizontal tunnels 4 feet wide by 7 feet high into the basalt underlying the high water table areas. Tunnels were terminated when fractures in the basalt carrying significant amounts of water were intercepted. The tunnels then served effectively as drainage channels to convey excess water into natural surface drains. Approximately 50 tunnels ranging from 0.25 to 1.5 miles in length were excavated before the practice was discontinued in the 1930's. After that, when drainage was needed in an area, a network of relief wells were drilled and connected by the lines. These relief wells were drilled 35- to 70-feet deep, and the tile lines connecting them were installed 3.5 to 10 feet below the ground surface. These wells flow from hydrostatic pressure and water is conveyed to natural surface drains by the tile lines. This practice also has proved effective in lowering the water table and it is still used today.

Sampling sites throughout the area included the project diversion at Milner Dam on the Snake River, 15 drainage tunnel outlets, 5 tile-relief well network outlets, 4 main natural surface drains, and approximately 15 small natural surface drains returning to the Snake River. These sites, except the small surface drains, are shown by number in Figure 1. Samples from each site, except the 15 small surface drains, were collected at two-week intervals for the Canal Company water year, October 1, 1968 through September 30, 1969. Surface runoff water samples were collected at irregular intervals during the study year. Weirs, flumes, and current meters were used to measure water flow at the sampling site. The quantity of water diverted was provided by the Twin Falls Canal Company in cooperation with the U.S. Geological Survey.

The water balance for the irrigation tract was computed based upon the following equation:

$$D + P = ET + G + Q \pm \Delta S$$

where:

D = all water diverted into the tract
P = precipitation
ET = evapotranspiration
G = subsurface drainage or deep percolation
Q = direct surface runoff
ΔS = change in soil-water content

Most of the diverted water, D, was measured at the Milner Dam diversion. The contribution from the South Hills watershed was estimated from U.S. Geological Survey records, and the small contribution from the city of Twin Falls was estimated from city records. Evapotranspiration, ET, was determined using a modified Penman approach. Precipitation was taken from Weather Bureau records. The direct surface runoff was measured and the subsurface drainage or deep percolation was estimated by difference.

However, more than one-half of this subsurface drainage water was measured. The change in soil-water content, ΔS, was considered negligible for this study.

The water balance (Table 2) shows that 50% of the total input water passed through the soil and became subsurface drainage. Evapotranspiration accounted for 36%, and remaining 14% was surface runoff. Thus, 64% of the total water input became irrigation return flow into the Snake River.

The mean electrical conductivity (EC) of the water diverted at Milner Dam averaged 460 µmhos/cm, with little variation (Table 3). This value was used for calculating the total salt input (Table 4). Surface runoff water had the same EC values as did the diverted water.

The total soluble salt concentration in subsurface drainage water was generally more than twice that in the irrigation water. The concentration was nearly constant for each tunnel and tile-well network, but there was some variation among them. There was no particular pattern to the variation among them. There was no particular pattern to the variation, and generally, differences were small. Thus, the mean EC value of 1,040 µmhos/cm was used for computing total salt outputs via subsurface drainage waters (Table 4).

There was a net output of 217,100 tons of total soluble salts in the subsurface drainage water. This represents approximately one tone of salt per acre per year. Results from these studies indicated that more leaching than necessary to maintain a salt balance is taking place. This high level of leaching assures against salt accumulation in the soil, but it also likely increases the salt output from the soil.

There was a net output of Ca^{++}, SO_4-S and HCO_3^- indicating that no precipitation of $CaCO_3$ and $CaSO_4$ was occurring under these excessive leaching conditions. More efficient irrigation would probably decrease the total salt load in the return flow and thus decrease the downstream salt load in the Snake River. However, decreasing the amount of input water, and hence the amount of subsurface drainage water, would result in an increase in a salt concentration in the subsurface drainage water. Some irrigators use this subsurface drainage water for irrigation purposes at the lower end of the Canal Company tract. If the salt concentration in this drainage water were increased, some salt problems may develop at the lower end of the irrigation tract.

Results from this irrigation study can be considered typical of may irrigated areas in the western United States. $CaCO_3$ and $CaSO_4$ are dissolved rather than precipitated under these conditions.

Changing Water Management to Decrease Pollution

As conservationists, our long range goal should be to manage irrigation water so that the amount of soluble salt in the subsurface return flow

TABLE 2. Water balance for the 203,000-acre Twin Falls Canal Co. tract for the year October 1, 1968 through September 30, 1969.

Source	Acre Feet	%
Input		
Diverted from Snake River	1,290,100	89
Runoff from South Hills Watershed	32,000	2
Precipitation	130,000	9
City of Twin Falls	900	--
TOTAL	1,453,000	100
Output		
Evapotranspiration	523,650	36
Surface runoff	203,880	14
Subsurface drainage	725,470	50
TOTAL	1,453,000	100

TABLE 3. Mean total salt and ionic concentrations in the irrigation and drainage waters of the Twin Falls Canal Co. irrigation tract.

Name	Site No.	Total Salts	Na^{+}	K^{+}	Ca^{++}	Mg^{++}	Cl^{-}	HCO_3^{-}	NO_3-N	SO_4-S	PO_4-P
		umhos/cm	me/l	me/l	me/l	me/l	me/l	me/l	ppm	ppm	ppm
Input Streams											
Snake River	1	460	0.90	0.12	2.54	1.23	0.66	3.38	0.12	14	0.066
Drainage Tunnels											
Claar	6	1,148	3.65	0.10	5.22	3.62	1.33	6.66	4.02	69	0.013
Fish Hatchery	7	867	2.92	0.13	3.55	2.85	1.30	5.57	2.24	36	0.013
Grossman	8	911	3.01	0.10	3.99	2.81	1.18	5.97	2.25	45	0.014
Nye	9	990	3.64	0.11	3.81	3.02	1.54	5.91	2.44	55	0.009
Tolbert	10	1,130	4.06	0.12	4.95	2.23	1.65	6.45	3.30	68	0.012
Walters	11	1,112	3.86	0.14	4.47	3.98	1.52	6.67	3.47	56	0.008
Mendini	12	1,106	4.73	0.21	3.60	2.88	1.72	7.22	3.97	47	0.009
Neyman	13	1,102	4.06	0.23	5.42	2.71	1.55	7.52	3.40	50	0.011
Galloway	14	982	3.82	0.12	3.88	2.94	1.19	7.12	3.58	35	0.014
Cox	15	973	3.38	0.12	3.81	2.96	1.24	6.74	3.44	35	0.015
Herman	16	1,076	3.00	0.12	5.71	3.01	1.42	7.08	3.00	47	0.017
Harvey	17	965	3.70	0.13	3.64	2.84	1.37	6.93	3.39	31	0.008
Peavy	18	984	3.93	0.13	3.57	3.12	1.57	6.47	3.02	36	0.007
Padget	19	1,000	3.92	0.13	3.46	3.34	1.62	6.24	3.01	42	0.008
Hankins	20	1,093	4.49	0.18	4.27	3.11	1.63	6.62	3.55	53	0.012
Tile-relief well complexes											
Brown	21	1,121	4.06	0.16	4.36	3.50	1.67	6.78	3.01	55	0.009
Hutchinson	22	1,106	4.38	0.21	4.15	3.06	1.61	7.65	3.20	44	0.012
Kaes	23	1.044	2.73	0.19	5.07	3.20	1.83	6.25	3.40	54	0.023
Molander	24	1,088	2.80	0.21	4.82	3.59	1.94	6.12	3.79	57	0.009
Harvey	25	1,000	3.67	0.14	3.59	3.10	1.42	6.27	3.30	36	0.023
Mean for subsurface drainage		1,040	3.69	0.15	4.27	3.14	1.52	6.61	3.24	48	0.012

TABLE 4. Total salt and specific ion balances for the Twin Falls Canal Co. tract for the year October 1, 1968 through September 30, 1969.

Component	Total Input	Total Output	Net Input	Net Output
	Tons	Tons	Tons	Tons
Total salts	520,977	738,077	----	217,100
Na^+	36,511	88,946	----	52,535
K^+	8,444	7,070	1,374	------
Ca^{++}	90,006	98,272	----	8,266
Mg^{++}	59,664	94,548	----	34,884
Cl^-	41,284	59,723	----	18,439
HCO_3^-	365,880	454,400	----	88,520
NO_3-N	210	3,226	----	3,016
SO_4-S	25,598	51,342	----	25,774
PO_4-P	116	28	88	------

will be at a minimum level that will allow sufficient leaching to maintain crop productivity. To attain this goal, irrigation efficiency must be increased in many areas. Our aim should be to manage the irrigation water so that harmless salts are precipitated and left in the soil while harmful salts are removed by leaching and drainage processes. We are accustomed to considering the salt balance of an irrigation tract based on input and output values without giving adequate consideration to precipitation processes that might occur in the soil.

As water is used by the crops through evapotranspiration, the salt concentration in the water remaining in the soil increases. When the concentration reaches the solubility concentration for a given salt, precipitation begins. The solubility concentrations for $CaCO_3$ and $CaSO_4$ are below concentrations harmful to most crops. Therefore, these materials can be precipitated in the root zone without decreasing crop production in many cases. The following equation represents the salt balance for any given irrigated area:

$$Ci\ Di = Sp + Cd\ Dd$$

where:

Ci = salt concentration in the irrigation water
Di = the depth or the quantity of irrigation water
Sp = salt precipitated in the soil
Cd = salt concentration in the drainage water
Dd = the depth or the quantity of drainage water

Because of water rights, systems design, tradition, lack of understanding, and other factors, Ci Di tends to approximate a fixed yearly quantity for many irrigation tracts. For the Twin Falls Canal Company tract, and likely many other tracts, Ci Di is large, Sp is 0 and Cd Dd exceeds Ci Di because excess leaching water comes in contact with fossil salts and enhances the dissolving of soil minerals. Thus, a salt balance is not being maintained, but salts are being removed from the soil that need not be for maintaining crop productivity.

The salt balance equation must be applied to minimize the salt output and pollution by salts. Sp should be the maximum allowable for a given irrigation tract for maintaining crop productivity. For many tracts, Ci Di will have to be decreased before any $CaCO_3$ or $CaSO_4$ precipitation will occur so that Sp will exceed 0. In other words, irrigation efficiency should be maximized. To improve irrigation efficiencies, better irrigation scheduling is needed. Redesigning irrigation systems will be necessary in some instances. In others, reconsideration of water rights or even changes in them may be required. We must manage our water wisely, and not misuse it.

PHASE III - AGENCY RESPONSIBILITIES, PROGRAM OBJECTIVES AND POLICIES

ENVIRONMENTAL PROTECTION AGENCH RESPONSIBILITIES, PROGRAM OBJECTIVES, AND POLICIES

Hurlon Ray

The establishment of the Environmental Protection Agency last December 2nd signaled the real beginning of a cohesive national effort to defend and enhance the environment. The very existence of EPA is a response to the growing realization across the nation that pollution control must become and remain a way of life.

EPA is an independent regulatory Agency, reporting to the President. Such agencies are independent of our substantive Cabinet Departments, such as Agriculture. A regulatory agency has quasi-judicial functions and that means that in areas defined by Congress and the President we are a law enforcement agency, and to a degree we function as police, as prosecutors, and as judges. We set standards. We evaluate public adherence to these standards. We enforce the laws requiring compliance with those standards.

EPA provides government with a mechanism to tackle pollution problems on a very broad yet consolidated front. We approach environmental control in its totality recognizing the interrelationship of forces which combine in the natural environment.

An important change for some of our component agencies is that they are no longer attached to the departments which had the additional function of promoting or accomplishing achievement in a given area. Our new agency, for example, has taken over pesticide regulation from the Department of Agriculture.

EPA brings under one organizational roof the Federal programs dealing with air and water pollution, drinking water quality, solid wastes, pesticides and environmental radiation. Authorities in all these areas which had been vested in a number of other departments, including the standards-setting responsibilities of the Atomic Energy Commission and the Federal Radiation Council, as well as pesticides registration and related functions of the Department of Agriculture, are now placed in EPA. In addition, recent legislation has given our agency specific responsibilities with respect to the noise problem.

In general, we are responsible for establishing and enforcing standards, monitoring pollution in the environment, conducting research and demonstrations, and assisting State and local governments in their pollution-control efforts.

Hurlon Ray, Acting Assistant Regional Director for Management, Region X, EPA, Seattle, Washington

EPA represents tangible movement to eliminate a fragmented, uncoordinated approach to environmental control. The establishment of EPA was an effort to slice through the jungle of bureaucracy which entwined and slowed environmental control efforts. Before EPA, two Federal Departments were responsible for determining the adverse effects of pesticides, and a third exercised legal responsibility for controlling the introduction of pesticides into the environment. Air and water pollution control authority rested in two separate Departments. Control of radiation hazards was split between the Public Health Service and the Atomic Energy Commission.

The consolidation and coordination of EPA's pollution control endeavors is beining carried over into the field where the pollution is and where the action is.

The field operations of EPA are managed by ten regions, matching the boundaries of the 10 standard Federal regions. The focal point of EPA operational programs will be the field where strong decision-making powers are delegated to the Regional Administrators. EPA Regional Administrators are fully responsive to State and local problems and needs.

EPA was established to make possible an integrated, coordinated attack on pollution, based on a view of the environment as it truly is--a single system of interdependent and interrelated parts. EPA is to fill the need, moreover, in the President's words, for "a strong independent agency" to serve as an objective, impartial arbiter of environmental matters, particularly in the standards-setting function.

EPA is working closely with the other two new environmental agencies: the Council on Environmental Quality, which advises the President and coordinates Federal policy and action in the environmental field; and the National Oceanic and Atmospheric Administration, in the Department of Commerce, which is responsible for long-range research on pollution problems of the future, especially global trends affecting the oceans and the atmosphere; and with all other Federal Agencies on matters affecting the environment.

This restructuring of the Federal effort is designed to implement the national policy defined by the National Environmental Policy Act--to encourage "productive and enjoyable harmony between man and his environment."

This new organizational structure places our Nation in a much better position to make orderly and effective progress toward understanding and controlling environmental hazards.

We in EPA believe we have a dual responsibility--we must be able to act quickly in those environmental matters that are urgent, and at the same time, we must be able to foresee and forestall what is coming. It is our tack, in other words, to roll back the tide of pollution that is the legacy of past apathy and ignorance, and at the same time help to initiate an orderly system of making choices affecting the future.

Water Quality Standards

The water quality standards program has been a joint Federal-State effort to protect and improve the Nation's waters.

Water quality standards have been adopted by all of the States and approved by the Federal Government. At the beginning of 1971, the standards of twenty-four States had been <u>fully</u> approved. In six States the only remaining problem is the anti-degradation standard. Of the remaining twenty-four States only eight States present significant problems.

Clearly we could not have achieved the standards of water quality we now have without a tremendous effort on the part of the States and their cooperation in working with the Federal Government in this complex task. Many of the States have extended and upgraded their own water quality requirements to include standards for intrastate waters, and have enacted legislation to require State discharge permits.

State Water Pollution Control Programs

Turning now to State Water Pollution Control Programs, the strengthening of these programs becomes increasingly important as we expand and accelerate our national water pollution control program.

From 1967 to 1971, we estimate that Federal grants to assist States in developing and carrying out their water pollution control programs will have increased 105%. During the same period the increase in Federal grants to interstate agencies will be 135%.

The $10 million in Federal program grant awards in fiscal year 1970 resulted in a total expenditure of approximately $36 million for State and interstate water pollution control programs.

While significant increases in both staff and budget were reported by State and interstate agencies for fiscal year 1970, only a few have achieved levels adequate to deal with their increased responsibilities. Guidelines have been furnished to assist the States in planning for and evaluating their staffing and budget needs. Expanded contact with Governors' offices, Attorneys' General offices and legislative leaders, and communications with State program managers, are resulting in a better Federal-State partnership and in increased State participation in program plan development.

Construction Grants

The construction of municipal waste treatment facilities is a key element in the attainment and enforcement of water quality standards. During 1970, approximately 1300 projects received Federal financial assistance under the Federal Water Pollution Control Act which resulted in the construction of $2.3 billion worth of municipal waste treatment facilities.

Now that substantially larger commitments of financial and other resources are needed for purposes of waste treatment facility construction, we must maximize the benefits of Federal, State, and local dollars in the planning, building, operation, and maintenance of treatment works to ensure a cost effective and efficient program.

In connection with our effort to direct this program toward these water quality goals, regulations were promulgated on July 2, 1970, which require that treatment works must be included in a basin-wide or area plan for pollution abatement, and must be designed, operated, and maintained to achieve maximum efficiency and economy. By including these treatment works in a comprehensive water quality managment process, we hope to relate investments in these works to the environmental quality management objectives of a basin, metropolitan area, or region.

Research and Development

EPA had placed a high priority on the Research, Development and Demonstration Program. We are giving primary attention to development of a sound scientific basis for the establishment and refinement of water quality standards, and research and demonstration of technology to control pollution from major sources.

Emphasis is being given to technology transfer, designed to assure the timely application of treatment techniques which have been developed.

A substantial research effort is being directed toward determination of water quality requirements for all water uses. Recent significant accomplishments include the establishment of acceptable concentrations in water of various pollutants for selected aquatic organisms.

We are accelerating our research efforts on water quality criteria for mercury, other heavy metals, petrochemical wastes, and chlorine compounds.

Special programs are now underway to characterize and quantify kinds and sources of polluting substances and their interaction with the aquatic environment. New research and demonstration efforts are directed toward:
1) demonstruction of pollution control in native Alaskan villages;
2) an analysis of manufactured products with water pollution potential;
3) rehabilitation of eutrophied lakes; 4) an analysis of the environmental compatibility of NTA as a substitute for phosphate in laundry detergents; and 5) development of an ultra-sensitive technique for decting and identifying heavy metals in water.

A major research effort has been focused on developing and demonstrating control technology for the following major sources of water pollution: municipalities, industries, agriculture, mining, vessels, and oil and hazardous materials.

Municipal wastes continue to be a major national source of pollution. EPA is seeking more effective and more economic means for treating these wastes. Highlights of our accomplishments during 1970 include improved methods of phosphorus removal, successful use of municipal sludge for agricultural purposes, and demonstration of new advanced waste treatment techniques for high quality water uses.

Industry presents one of the largest and most difficult pollution problems. Our cooperative industry-government program is designed to develop and demonstrate effective technology for controlling pollution from all major industrial sources, at minimum cost.

Agricultural wastes are often difficult to collect and treat. EPA's expanding program is seeking imaginative solutions to such problems as animal and poultry waste treatment, irrigation management, and control of runoff from pesticides. Demonstration during 1970 related to the reduction of salt and nitrate concentrations in irrigation waters and control of runoff from animal feedlots.

Mining pollution causes major problems, often in streams in rural and semi-wild areas with great recreational potential. A three-year effort has resulted in some twenty completed projects, including improved understanding of the formation of mine drainage, development of new and potentially low cost methods for "plugging" mine discharges, and development of a new method for treating mine drainage.

EPA is developing new technology to prevent, control and mitigate the effects of the thousands of oil spills occurring annually. Among accomplishments in 1970 were: successful demonstration of a unique high capacity centrifuge to separate oil from water; development of beach cleaning techniques most recently used at San Francisco with great saving of time and cost; and a major program of technology transfer for application during spill incidents.

EPA's program on control of pollution from combined and storm sewers has realized several significant accomplishments. A new process for electrochemical disinfection of storm waste water has been developed. Full-scale systems for treating combined sewer overflows by screening and dissolved air floatation have been implemented. A storm water management model has been developed and is being test-demonstrated. Technology developed by this program over a very short period of time permits us to move forward in addressing the abatement of pollution from these combined sources.

Refuse Act Permit Program

Another State-Federal environmental protection effort, announced by the President on December 23, 1970, in Executive Order 11574, is the Refuse Act Permit Program. This program, to be administered by the Army Corps of Engineers in cooperation with EPA, will involve implementation of the Refuse Act of 1899, which requires that a permit be obtained for all discharges, other than discharges from sewers, into navigable waters or their tributaries. The corps may not issue a permit, however, unless pursuant to the requirements of section 21(b) of the Federal Water Pollution Control Act,

the State in which the discharge will originate has certified that such discharge will not violate applicable water quality standards. The Corps may not issue the permit if the State denies certification. EPA reviews permit application and State certifications and in connection with such review advises the Corps with respect to the meaning and content of water quality standards, their application to the proposed discharge, and the permit conditions required to comply with standards and to carry out the purposes of the Federal Water Pollution Control Act. The Corps accepts EPA's advice on matters pertaining to water quality standards and related considerations as conclusive and will not issue a permit where to do so would be inconsistent with EPA's findings, determinations and interpretations.

By requiring dischargers, including agricultural to obtain permits for all discharges into navigable waters, we will be able to address existing and potential pollution problems before further damage is done.

We intend to use this program to strengthen the regulatory capabilities of State and Federal pollution control authorities. We believe that the clarification of standards and requirements applicable to individual dischargers, which will be achieved in connection with the consideration and disposal of individual permit applications, will be a significant benefit to State and Federal pollution control authorities as well as to the dischargers themselves.

EPA's Authority to Require Environmental Impact Statements

EPA does not have direct authority to require impact statements. However, the Administrator of EPA can not carry out his legal requirements of Section 309 if statements are not prepared.

Section 102 (2)(C) of N.E.P.A. requires all Federal agencies to "include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement..." "Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise..."

Section 309 of the Clean Air Amendments of 1970:
(A) The Administrator shall review and comment in writing on the environmental impact of any matter relating to duties and responsibilities granted pursuant to this Act or other provisions of the authority of the Administrator, contained in any (1) legislation proposed by any Federal department or agency, (2) newly authorized Federal projects for construction and any major Federal agency action (other than a project for construction) to which section 102 (2)(C) of Public Law 91-190 applies, and (3) proposed regulations published by any department or agency of the Federal Government. Such written comment shall be made public at the conclusion of any such review.

"(b) In the event the Administrator determines that any such legislation, action, or regulation is unsatisfactory from the standpoint of public health or welfare or environmental quality, he shall publish his determination and the matter shall be referred to the Council on Environmental Quality."

The Corps of Engineers submits 102's on individual drainage projects, erosion control projects, dredging projects, and all major navigational, flood control projects.

The Bureau of Reclamation submits 102's on all irrigation projects.

The Bonneville Power Administration submits one 102 for each fiscal year with a breakdown for each transmission line.

The Oregon, Washington, Idaho, and Alaska Departments of Highways submit a separate 102 for each section of highway, and negative declarations for smaller projects like signing, lighting, etc.

Housing and Urban Development submits statements for each project.

The Federal Power Commission submits statements for each new or relicensed project.

The Federal Aviation Administration submits a 102 for each airport construction project including runway extensions.

Region X EPA has not received any 102's from the SCS as to date.

The long-range intent of the N.E.P.A. is to instill in Federal agencies an environmental ethic. The 102 statements are proving to be an excellent method of insuring that environmental considerations become a part of the daily working activities of the agencies.

The Calvert Cliff court decision has established that submitting statements only if a project becomes controversial does not carry out the intent of the law.

EPA shares with you an appreciation for the awareness of pollution and the ecological consequences of agricultural wastes. Mounting water and air quality problems make it evident that our past practices of washing the wastes away can no longer be tolerated.

As you know, the President, when signing HR 17923, the Department of Agriculture and Related Agencies Appropriation Act, which funds the former ACP program, proposed a changed program with new objectives, and to lend emphasis to these changes, he renamed the program to the Rural Environmental Assistance Program. He asked that the program be:

1. Changed to focus on preserving our environment.
2. Changed to focus on demonstration of good environmental enhancement practices.
3. Changed to return more public benefits at less public cost.

The Environmental Protection Agency, has responsibilities for air and water quality, solid wastes, pesticides, and radioactive radiation. EPA is concerned primarily with the preservation of the environment and is, therefore, interested in USDA's Program and its plans to preserve our environment, demonstrate good practices, and return benefits to the public.

Some of the rural activities which can be sources of water quality degradation are animal wastes, rural runoff, irrigation, forestry and logging, which, when applied, assist in preventing water quality deterioration. Last year, some of the states developed new practices such as reducing pollution of water by farm wastes--the runoff from barnyards, dry lots, and feedlots; farm waste control--to catch water, sediment, and other material from farm areas subject to sediment runoff and transport of pollutants; pollution and sediment control--dams, pits, diversions, and terraces to control runoff and sediment from feedlots and barnyards; and, construction of farm animal waste disposal systems--lagoons, ponds, and dikes.

The objectives of control programs are to prevent or reduce the degradation of water quality from bacteria, sediment, nutrients, and pesticides. Measures which reduce rural runoff will be effective in meeting these objectives and are many, such as: efficient irrigation, erosion control, vegetation control, grassed waterways, and buffer strips next to cultivated lands and next to streams. Bacteria and nutrient control can be assisted by giving attention to fertilizer practices, farm animal management, and waste handling. Things which can be done in barnyard and feedlot operations are site selection, feedlot or barnyard design, and management of the liquid and solid wastes.

In assuming your vital share of protecting the Nation's water and soil resources, I urge you to accept the challenge through personal commitment to the necessities of environmental preservation and enhancement; and through professional innovation in translating your commitment to thoughtful action. Let us demonstrate that we do have the national will to preserve and restore a valued part of our national heritage.

Participation, coordination, and partnership--there can be no silent partners, no secrets, in this arrangement and each of us must participate in areas of joint concern to our fullest capabilities.

President Nixon has said that "The 1970's must absolutely be the years when America pays its dept to the past by reclaiming the purity of its air, its water, and its living environment." Each of us has a role to play in fulfilling that mission. Only the total involvement of all of us--as citizens and as consumers, and as government officials can make this the decade when we restore and protect the earth for all the children of tomorrow.

CORPS OF ENGINEERS ROLE

IN THE DISCHARGE PERMIT PROGRAM

Frank Bertinchamps

In line with the theme of your workshop and in complement to what Mr. Ray has covered, I would like to briefly discuss the 1899 River and Harbor Act, its history and our current pollution abatement activities related to this law.

Legal precedent for national interest and jurisdiction over navigable waters which lead to the 1899 law has deep roots in history. This law reflects the accepted doctrine that people have both public and private rights in navigable waterways, just as such waterways are affected by both a national and state interest. This doctrine traces its history from the common law of England. Originally, the King was vested with absolute title over all tide waters and the land under them. A subject could acquire a right in either land or water only by grant from the King.

Under the Magna Charta which King John was forced to sign at Runnymede in 1215, the people at large secured two important rights in tide waters, those of navigation, and fishery. Recognition was also secured by the people of a right of navigation, above the ebb and flow of the tide, in all rivers which were capable of such use. Thereafter, title to the land and water was held by the King in trust for the public easement. The power of regulation was therefore vested in Parliament. At the settlement of the American Colonies, these rights passed to the grantees in royal charters. When the original thirteen states established their independence, they automatically became vested with the title and the dominion over navigable waterways and the lands under them. This exclusive control over navigable waters, their shores and beds, as well as regulation of commerce, resided in the several states up to the ratification of the Constitution of the United States.

Our constitution provides that "Congress shall have power to regulate commerce with foreign nations, among the several states, and with Indian tribes," and by this provision there was transferred from the states to the federal government the control of all the navigable waters of the country for the purpose of navigation.

Now, let's consider for a moment the "Environment" and the problems we had in this country at the turn of the century when the River and Harbor Act of 1899, a section of which is called the Refuse Act, was passed.

Accordingly, we have briefly scanned some of the publications of the time and found the "Engineering News" which was then a weekly journal of Civil, Electrical, Mining and Mechanical Engineering to be particularly revealing.

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We found that then, as now, we were concerned with pollution and environment; however, the main pollution problem was sewage and garbage. In 1899, typical modern sewage treatment provided only settling or screening of solids with raw effluent being discharged into a nearby waterway. It was entirely acceptable for coastal cities to discharge unscreened raw sewage and occasionally garbage directly into the ocean or estuaries. There were many areas, even in the large cities, without sewers. The so-called "Nite Soil" from homes was then collected by the city or contract collector for final disposal. Garbage was commonly buried, dumped in the ocean or waterway, fed to the hogs, or buried in shallow trenches to fertilize the fields. Burning, of course, caused air pollution and odor problems as it does now.

There was much concern over clean water supplies and justly so. In Philadelphia, in a two-month period in 1899, there were nearly 4,000 cases of typhoid resulting in over 400 deaths. This was traced to a domestic water pump intake which was found to be only one mile downstream from a sewer outfall.

Railroad travel was realtively hazardous. Wrecks were frequent and each issue of the Engineering News carried a news item captioned "The Most Serious Railroad Accident of the Week". In 1899 there were over 7,000 fatalities from railroad accidents.

There was competition over use of waterways. Navigation versus bridges, dams, causeways and fills. Other items of interest included: An article expressing concern over the world's diminishing wheat supply.

An article on the diminishing resources of the world and rising population. The author predicted that before the end of the 20th century, the world's commerce would likely be carried on sailing vessels because of a projected coal shortage.

There were several articles debating the merits and justification for paving streets and roads and how much to pave - curb to curb or a narrow center strip. Ironically, the general conclusion seemed to be that paving could not really be justified on an economic basis but it was sure nice to have.

In 1899, the Russian Calendar was twelve days behind other nations and a commission had been formed to investigate the merits and problems of changing it.

Wireless telegraphy was successfully used by Marconi in transmitting the news of the international yacht race to the New York Herald. The Army and Navy observed and stated that further tests will be made in the interest of the Government.

A new sewage system was proposed for San Francisco. It was designed for a population of one million and provided for dumping the crude sewage into the Bay. It noted that the Bay was capable of absorbing it for a long time to come.

On the 3rd of March 1899, the Congress of the United States passed the River and Harbor Act. Ironically, the appropriations for Civil Works and Section 3 of the Act directing the Corps of Engineers to investigate the Isthmus of Panama with a view to construction of a canal by the United States, were the only items worthy of mention at that time in the Engineering News. This Act, however, also contained provisions for protecting the public right of navigation and use of the waterways which today, together with subsequent legislation and court decisions have become increasingly important in environmental protection.

Section 9 of the Act stated that it is unlawful to construct any dam, dike, causeway in any navigable water of the United States without Corps of Engineers approval of plans.

Section 10 of the Act prohibits the dredging, filling, erection of structures or the creation of any obstruction to the navigable capacity of any waterway of the United States unless authorized by a permit issued by the Corps of Engineers.

Section 11 provided for Corps of Engineers establishing harbor lines beyond which no structures or fills would be permitted except upon approval by the Corps of Engineers.

Section 13, commonly called the "Refuse Act", prohibits the discharge of any matter of any kind other than that flowing from streets and sewers in a liquid state into any navigable water of the United States or tributary of such waterway from which the same shall be washed into such waterway.

This section also provides that the Secretary of War, whenever in the judgment of the Chief of Engineers, anchorage and navigation will not be injured thereby, may permit the deposit of such matter within limits to be defined and under conditions to be prescribed by him. This is the basic authority for the new discharge permit program which I will discuss later.

Sections 12 and 16 provided penalties of $500 to $2,500 and imprisonment of 30 days to one year for violations of the Act.

In summary, it appears that this 1899 Act was essentially intended to protect the Public right of navigation. The words navigable or navigation appear over 20 times in the relatively short sections of the Act that pertain. Accordingly, the permit authority granted to the Corps under this Act was exercised for a long period of time only from the viewpoint of how the proposed works or discharge would affect navigation.

Through the years, the application of this law was often tested in court and was gradually broadened. It was established that the term "refuse" included discharges of valuable oil; that it covered inadvertent discharges; that it covered the discharge of solids suspended in liquid; and that it covered discharges onto the ground in circumstances where it could then be carried into the water by gravity. Some of these court decisions were anchored in subsequent legislation, such as the Oil Pollution Act of 1924. But in all these cases one assumption remained unchallenged. That was the assumption that the law intended us to consider only the effects of the discharge upon navigation, in deciding whether or not to grant a permit.

Permit applications describing the proposed work were the subject of public notices and given wide distribution. Permits issued were exclusively related to structures, dredging and fills under Section 10. There was no formal Refuse Act permit program; however, the Refuse Act was enforced and violators were prosecuted. In its place and time, this limited viewpoint fulfilled the public need.

Beginning in the 1950's however, people were becoming more and more concerned with the environment, particularly with respect to our waterways. This concern was reflected in legislation beginning with the Fish and Wildlife Coordination Act of 1958 and court decisions giving a more liberal interpretation of the 1899 law.

In response, Corps of Engineers administration of the 1899 law was gradually changed to give more and more consideration to factors other than navigation in evaluating permit applications.

Today, our procedures for evaluating applications for dredging, structures and fills under Section 10 require consideration of all factors affecting the public interest including fish and wildlife, navigation, economics, water quality, conservation, aesthetics, ecology and all other environmental factors. Thorough coordination is required with all Federal agencies and State and local authorities prior to denial or issuance of a new permit or modification of an existing permit. Public notices are issued describing the proposed work and comments solicited. Public hearings are held in controversial cases.

When outfall works are involved, the applicant must provide complete details on the character and content of the effluent even though it may be sewage which is exempt from the provisions of the Refuse Act (Section 13). Thus a sewage discharge is considered and correspondingly controlled through Section 10 of the Act if the outfall structure extends into the navigable waterway.

Applicants must now not only define areas to be filled or structures in the waterway but also indicate the use and buildings to be placed on such structures and fills. A significant change in use or outward appearance will correspondingly now require a new permit.

These changes were in effect even before the National Environmental Policy Act of 1969 which essentially states that every Federal agency shall consider ecological factors when dealing with activities which may have an impact on man's environment.

The Water Quality Improvement Act of 1970 knitted the states tightly into the pollution control fabric by providing that any applicant for a Federal license or permit to "...conduct any activity, which may result in any discharge into the navigable waters of the United States" must obtain certification from the State, in which the discharge originates that such discharge will not violate applicable water quality standards, before such Federal license or permit can be granted.

In December 1970, the President issued an Executive Order to enforce the control of water pollution under the Refuse Act of 1899. These discharge permits under the Refuse Act would be required for all discharges (except sewage) into navigable waterways and their tributaries. This permit program is now underway in close cooperation with the states and EPA and regulations were published requiring all dischargers to apply for a permit by July 1971.

Prior to issuing permits, we will require certification from the appropriate State or interstate water pollution control agency that the proposed discharge will not violate applicable water quality standards. Permit applications under this program are being judged on the basis of the effect the discharge may have on:

a. Anchorage and navigation.

b. Water quality standards and related water quality considerations.

c. Fish and wildlife considerations not reflected in or adequately protected by water quality standards.

The Environmental Protection Agency makes determinations on behalf of the Federal Government for the water quality aspects of the Refuse Act program and no permit will be issued contrary to the recommendation of either the Administrator of EPA or the appropriate State or interstate agency.

The permit program currently includes all dischargers into navigable waters or tributaries with the following exceptions:

a. Discharges or deposits into a public sewage treatment system.

b. All domestic sewage.

c. Discharges or deposits from a public sewage treatment system.

d. Storm water runoff from streets and sewers.

e. Discharges into a private treatment system (discharges from such treatment system are included, however.)

f. Discharges resulting from placing deposits on banks of streams where they may be washed into the navigable waterway by high tides or storms.

g. Discharges or deposits from ships.

h. Agriculture runoff and irrigation return flows (Administrative Determination) and feedlots except those under the following criteria:

Confined feeting operations which had an inventory of one thousand animal units at any one time in 1970 and which have a defined discharge into a navigable stream or tributary. An animal unit is that which has a biochemical oxygen demand equivalent to one beef steer. One thousand animal units is equivalent to 700 dairy cows, 4,500 butcher hogs, 1200 sheep, 35,000 feeder pigs, 55,000 turkeys, 180,000 laying hens, or 290,000 broilers. Others are exempt at this time.

i. Leaching (diffuse source) is not included at this time.

To date in this Division, which includes the states of Alaska, Washington, Oregon, Idaho, and parts of Montana, we have received and are now processing over 1,300 discharge applications under this program.

This concludes my prepared remarks. I have with me a reprint of a recent article by General Koisch, Director of Civil Works, entitles "In the Broad Public Interest", which supplements the information I have briefly presented. I will be glad to answer any questions that you may have, either now or later, as will best fit the program.

POLLUTION ABATEMENT THROUGH RESERVOIR REGULATION

Carver E. Hildebrand

The Corps of Engineers has the responsibility to operate its projects for all authorized project purposes. The Corps also has the responsibility to direct the flood control regulation of certain other multiple-purpose projects. In meeting this responsibility, it is the policy of the Corps of Engineers to regulate these reservoirs so as to provide optimum benefits for all authorized functions. That is to say, the Corps attempts to regulate its reservoirs and those of others in such a way as to reach the best possible balance among their sometimes conflicting functions.

In attempting to optimize benefits or reach the best possible balance among functions, it is not the Corps' policy to attempt to maximize revenues or even to obtain optimum dollar benefits. Many intangible benefits, which are difficult to express in terms of dollar benefits, must also be taken into account. To regulate projects for optimum revenue or tangible benefits would generally result in the power and flood control functions dominating other less tangible but nevertheless important project purposes.

The subject of this presentation notwithstanding, pollution abatement as such is not an authorized purpose of most Corps of Engineers' projects. However, low-flow augmentation for navigation, recreation and fish and wildlife is a commonly authorized purpose. And minimum reservoir releases and minimum flows at downstream control points are prescribed operating criteria. These minimums, which do much to enhance water quality and abate water pollution, are nevertheless for other purposes.

The general effect of reservoir regulation on river flows is to smooth out seasonal extremes. Using the Columbia River as an example, reservoirs are filled during the spring freshet, thereby reducing flood levels. They are maintained full during the summer months for recreational purposes and then evacuated during the fall and winter months to meet power demands and to provide augmented flows for navigation.

This low-flow augmentation does much to abate pollution of the Columbia River. Historically, during the winter months, flows of the Columbia River at The Dalles have been observed to be as low as 40-thousand cubic-feet-per-second for protracted periods. With present day reservoir regulation, winter-time flows will never again reach those extreme lows since mean weekly flows greater than 120 thousand cubic-feet-per-second are required to meet power demands during the winter.

Another example of the ironing out of seasonal variations in river flow by reservoir regulation may be had in the Willamette Basin and in the coastal streams of Oregon and Washington. Here extreme flood flows occur

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as a result of winter rains. During the summer and early fall months there is virtually no rainfall resulting in extremely low unregulated streamflow. Reservoirs on those streams are evacuated in the fall and their storage space is used during the winter to regulate winter floods. They are filled during the spring and held near full during the summer for recreation. During late summer and early fall their evacuation results in a marked augmentation of downstream flow.

Regulation of the Willamette River during late summer is a spectacular example of low-flow augmentation and resultant pollution abatement through reservoir regulation. This year, for example, beginning in late August it is planned to maintain the river flow at more than 11 thousand cubic-feet-per-second as measured at Salem, Oregon. It is estimated the unregulated flow of the river will be near 3,000 cfs at that time. Our primary goal in this regulation is to maintain the dissolved oxygen in Portland Harbor and at other points on the lower Willamette River at more than five parts per million at a time of the year when it might otherwise fall to less than two parts per million.

A principal beneficiary of this improved water quality is the recently introduced fall run of chinook salmon on the Willamette River. Because of low natural river flows during the fall, coupled with the natural barrier of Willamette Falls, no such run existed historically. As a result of the efforts of the Oregon Department of Environmental Quality over the past couple of decades in reducing sources of pollution on the Willamette River and the Corps of Engineers low-flow augmentation over this same period of time, it became feasible for the Oregon Fish Commission during the last several years to upgrade the fish ladders at the falls and introduce a run of fall chinook salmon on the Willamette. To date this effort has proven to be highly successful.

Pollution abatement is not an authorized function of the Corps' Willamette projects. As a result of the low-flow augmentation there is some loss to the power function and to at-site recreation on the lakes behind these dams, both of which are authorized functions. Nonetheless, during the past 20 years the Corps of Engineers has stretched its authority to regulate the Willamette projects for navigation to justify the greater releases being made for water quality enhancement. Twenty years ago our efforts to enhance flows were puny due to the few projects and limited storage available. But as more storage projects were completed, we revised our low-flow enhancement goals upwards. Recently, with the growing awareness of environmental considerations, there has been increasing popular support for our low-flow enhancement.

I have discussed at some length the Willamette Basin as a specific example of pollution abatement through reservoir regulation. This is a result of the fact that the Willamette is a good example and a basin with which I am well acquainted. I would now like to make some more general observations of pollution abatement through reservoir regulation.

In our modern industrial age we cannot ever hope to "return to nature" insofar as use of our rivers is concerned, and we cannot realistically hope to attain 100 percent pure water in our rivers. Industrial wastes, sewage, return flows from irrigated lands and other sources of river pollution must be controlled but cannot be entirely eliminated. Removal of 95 to 98 percent of the contaminants by treatment is a tenable goal of waste treatment. But the costs of removing the last two to five percent of harmful pollutants frequently becomes prohibitively expensive. It is for this reason that low-flow augmentation as a part of our multiple-purpose reservoir regulation becomes valuable. Dilution of residual pollutants to, say, one-fourth of the concentrations they would otherwise have is an important function of reservoir regulation.

We must avoid the tendence we sometimes have toward doctinaire solutions to our problems. Alternative solutions are usually available to most problems of pollution abatement. All available options should be taken into consideration. And it is generally true that the best practical solution to pollution problems is not to be had by any one means but rather by a combination of means such as limiting the dumping of wastes, treating wastes, and diluting the residual effluents which enter our rivers.

We must be patient and persistent in our efforts to clean up our rivers. While environmentalists have long preached their concern for our rivers and the need to preserve them in an uncontaminated state, it has been only during the last two decades their voices have been heard and heeded. Time and resolve are required to undo more than a century of rapid industrial growth and its attendant abuse of our rivers.

So far my discussion has been for the more part concerned with the abatement of pollutants such as industrial wastes which are discharged into our rivers. I would like to add a few comments on measures being taken to control two other important pollutants of our rivers: thermal pollution and nitrogen supersaturation. With regard to thermal pollution, reservoir regulation offers a practical solution. The cold waters released from the lower levels of storage reservoirs are capable of marked cooling of our rivers. During the summer months it is possible to reduce river temperatures by as much as 20 degrees F. by storage releases.

Unfortunately the cold water available from depths of storage reservoirs is frequently too cold for fish life immediately below the reservoirs. Multiple-level intakes must be provided for turbines and outlet works to allow selective withdrawal of water such that warmer water may be discharged. Temperature control of the Rogue River is one of the major justifications for the Lost Creek Project which is currently under construction. Fall Creek, Cougar, Dworshak and Libby are other Corps of Engineers' dams which have means of selective withdrawal of water.

The recently discussed nitrogen supersaturation problem on the Columbia River is largely a result of dam construction although it exists to a lesser degree in nature. The crux of the problem lies in the fact the

Lower Columbia and Snake Rivers were developed by a series of overlapping run-of-river projects. These projects were designed to permit upstream and downstream migration of anadromous fish, while developing the river for navigation and power. Their lack of storage capacity does not permit them to control the flow of the river. The usable storage capacity of these run-of-river projects is less than one-day's flow of the river. Uncontrolled river flows plunge over their spillways resulting in high levels of nitrogen supersaturation.

The headwaters reservoirs of the Columbia River system are likewise inadequate to control this mighty river. The immense flow of the river and its relatively small amount of reservoir storage makes control of the Columbia less than adequate for this purpose. Both the Colorado and Missouri Rivers have storage capacities which are four times their annual runoff. In the case of the Columbia the average annual runoff is some four times as large as the available storage capacity of its reservoirs.

Measures currently being taken to mitigate nitrogen supersaturation of the Columbia River include slotted gates placed in skeleton generating unit bays which can pass water through the dams without causing nitrogen supersaturation. Other means such as flip lips on spillways and energy dissipaters in operating generating units are under investigation. The obvious solution of additional upstream storage to control the river is largely precluded by lack of available storage sites and economic considerations. Feasible reservoir sites are preempted by environmental and other considerations. High costs and declining power and flood control benefits make economic justification of additional storage increasingly difficult.

If additional reservoir storage is to be developed to reduce river pollution, pollution abatement must be willing to bear its share of the allocated storage costs. While water quality has been enhanced by reservoir regulation, these benefits have been paid for by other project functions. If future projects are found to be desirable for water quality enhancement, it will be necessary that part of the cost be borne by this function.

At the present time a plethora of water resource studies are underway for the western United States. They range from numerous individual project studies being made by agencies such as the Soil Conservation Service, the Bureau of Reclamation and the Corps of Engineers, to the West-Wide Water Study of the Bureau of Reclamation. They include the Pacific Northwest River Basins Commission's studies of Puget Sound Drainage, of the Willamette Basin and its comprehensive framework study of the Columbia-North Pacific Region. Many state agencies are also inventorying and planning the future development of their water resources.

The North Pacific Division, Corps of Engineers is currently embarking on its fourth Columbia River and Tributaries Review Report. Previous reports in this series, largely determined the present water resource development of the Columbia Basin. The current report, unlike past reports, will be concerned with the future operation of the large system of projects which the Corps had planned and helped to build as well as future water resource developments. As a result of the changing emphasis on water resource use,

the report will give increased emphasis to such aspects of project operation as recreation, environmental impacts, as water quality control. The cooperation and participation of this group can help to make our future water resource developments and its operation responsive to today's needs.

POLLUTION ABATEMENT: DEPARTMENT POLICY

T. C. Byerly

The Department's programs have for many years taken account of the quality of the environment and its corollary, pollution abatement. Thus, the Forest Service has multiple use policy by statute--water harvest, wildlife habitat, recreation, preservation of wilderness areas, grazing for wild herbivores as well as livestock and timber harvest. The Soil Conservation Service is based on the conservation use and management of our soils and associated waters to maintain and enhance their productive capacity.

Recently, as concentration and intensification of man's activities have resulted in pollution of substantial masses of air, water, and land, the interest of the general public, including those far from the scene of pollution has been asserted and recognized.

Policy on pollution rests on the perception that pollution degrades the quality of the human environment and that, therefore, it should be prevented or abated.

Policy emerges from concensus.

Policy is asserted by executive, legislative, and judicial declaration. Policy is challenged by people adversely affected, or simply in disagreement. Policy is modified as it is applied in practice. Policy is modified by implementing it--by law, regulation, observance, and deviation. Department policy, present and emerging, must be considered in the context of all these considerations.

We shall begin with a statement from President Nixon's first State of the Union message: "We must create a new rural environment which will not only stem the migration to urban centers but reverse it. If we seize our growth as a challenge, we can make the 1970's a historic period when by conscious choice we transformed our land into what we want it to become."

That new rural environment must provide the clean air and water; green and growing fields, pastures, ranges and abounding wildlife; pleasant communities with adequate water and sanitary systems. All these environmental parameters depend for their quality on effective technology for soil and water management and its application.

Our concern with the rural environment is a part of our concern for the quality of the human environment--rural and urban, natural and managed, atmosphere, hydrosphere, lithosphere, biosphere.

A major step in formulation of environmental policy, ergo policy on pollution through soil and water management was marked by the enactment of the

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National Environmental Policy Act of 1969 which became Public Law 91-190 on January 1, 1970.

The Act further states that the Federal government is to use all practical means, consistent with other essential considerations of national policy to, among other responsibilities, attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences; enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Section 101 C of the Act is particularly significant. It states that: "The Congress recognizes that each person has a responsibility to contribute to the preservation and enhancement of the environment."

The next section, 102, is the one that spells out the implementative of policy. Section 102 states that: "The Congress authorizes and directs that, to the fullest extent possible: 1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act.

Now let us turn to Section 102 C which is the basis for the development and use in decision making of environmental impact statements. Section 102 C states: "include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on--

(I) the environmental impact of the proposed action,
(II) any adverse environmental effects which cannot be avoided should the proposal be implemented,
(III) alternatives to the proposed action,
(IV) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and,
(V) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

"Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, Council on Environmental Quality and to the public as provided by section 552 of title 5. United States Code, and shall accompany the proposal through the existing agency review processes."

The Council on Environmental Quality, established pursuant to Public Law 91-190, has issued guidelines for the implementation of Section 102 C on April 23, 1971. (Federal Register 1971, 36-7724-7729)

The policy paragraph of these guidelines states: "As early as possible and in all cases prior to agency decision concerning major action or recommendation or a favorable report on legislation that significantly affects the environment, Federal agencies will, in consultation with other appropriate Federal, State, and local agencies, assess in detail the potential environmental impact in order that adverse effects are avoided, and environmental quality is restored or enhanced, to the fullest extent practicable. In particular, alternative actions that will minimize adverse impact should be explored and both the long and short range implications to man, his physical and social surroundings, and to nature, should be evaluated in order to avoid to the fullest extent practicable undesirable consequences for the environment."

Following the enactment of Public Law 91-190, on May 28, 1970, the Secretary of Agriculture issued Secretary's Memorandum Number 1695: "Protecting and improving the quality of the environment."

"1. Background. Plants, animals, fish, wildlife and microorganisms and the soil, water, air, and landscapes they share must be protected and managed so that the production and derivation of farm, range, and forest products and benefits will assure and increase the ecological utility and productive capacity of these resources. Forests, wild lands, wetlands, natural areas, farms, ranches, and rural communities must continue to provide water, wildlife habitat, recreation areas, energy sources, transportation routes, diverse employment opportunities, space for living with amenities and services and scenic beauty, while producing food, fiber, and forest products as needed.

"2. Policy. It is the policy of the Department of Agriculture to direct its programs toward managing the environment for the widest range of beneficial uses without its degradation or risk to health or safety or other undesirable consequences.

"Department programs vitally affect the conservation and management of the Nation's land, water, and related biological, recreational, and esthetic resources. The Department must give increased attention to protecting and improving the quality of the environment in addition to its responsibilities for producing food, feed, fiber, and forest products; maintaining income and employment; and providing amenities and services.

"In its efforts to protect and improve the environment, the Department will coordinate its activities and programs with those of other public and private agencies and individuals. It will continue to act in concert with Federal and State agencies, land-grant colleges and universities, other educational and social institutions, conservation and other landowners and users. It will provide its competences as needed in dealings of the United States with other countries and international organizations.

"The Department will insure that its own facilities are designed, operated, and maintained and its programs conducted in ways to provide leadership in the nationwide effort to protect the quality of our environment.

"3. Implementation. In fulfilling its responsibilities concerning the environment, all agencies of the Department will direct special attention to those programs which contribute to protecting and improving the quality of the environment. These programs include but are not limited to:

"a. Protecting man, crops, livestock, forest, and the environment from pests--insects, weeds, diseases--fire, wind, and water in a manner safe for both man and the environment.

"b. Using range and forest land not only for efficiently producing commodities, but also for yielding water, wildlife habitat, recreation, scenic beauty, and other amenities.

"c. Providing services--electricity, water systems, sewage treatment, telephones and housing, technical assistance, extension education, and information.

"To these must be added:
"d. Preventing, controlling, and ameliorating pollution and eventually recycling and reusing waste--from accumulated animal, crop, and processing wastes; sediment; sewage; solid wastes from cities and industries; pesticide residues; smoke from wildfires and forest and crop residue burning; pollens; and natural toxicants.

"e. Investigating and providing information on interactions between man and his environment necessary to the development and application of knowledge and technology essential to wise management of the environment.

"In accordance with the objectives outlined above, the Department will propose and implement as authorized, new policies and programs in order to protect and improve the quality of our environment."

A correllary memorandum, Secretary's Memorandum Number 1666, "USDA Policy on Pesticides" had been issued on October 23, 1969. As pollutants of air, water, soil, and the biosphere, pesticide chemicals have been and continue to be of public concern. An excerpt from this memo follows:

"It is the policy of the Department of Agriculture to practice and encourage the use of those means of effective pest control which provide the least potential hazard to man, his animals, wildlife, and the other components of the natural environment.

"For the foreseeable future, pesticides will be necessary tools for the protection of the nation's food and fiber supplies, people, and their homes.

"Where chemicals are required for pest control, patterns of use, methods of application and formulations which will most effectively limit the impact of the chemicals to the target organisms shall be used and recommended. In the use of these chemicals, the Department has a continuing concern for human health and well-being and for the protection of fish and wildlife, soil, air, and water from pesticide contamination.

"In keeping with this concern, persistent pesticides will not be used in Department pest control programs when an effective, nonresidual method of control is available. When persistent pesticides are necessary to combat pests, they will be used in minimal effective amounts, applied precisely to the infested area, and at minimal effective frequencies.

"Nonchemical methods of pest control, biological or cultural, will be used and recommended whenever such methods are available for the effective control or elimination of target pests. Integrated control systems utilizing both chemical and nonchemical techniques will be used and recommended in the interest of maximum effectiveness and safety."

The Department, as directed in Executive Order 11514, has now developed draft guidelines for impact statements, which it will submit for final consideration as soon as conformity with current OMB requirements is achieved.

The policy paragraph of these draft guidelines, which will become Secretary's Memorandum 1695, Supplement 4(Revised), states:

"It is the policy of the Department of Agriculture to use the general approach of Section 102(2)(C) as a significant part of its procedures to 'monitor, evaluate, and control' its activities for the protection and enhancement of the quality of the environment on a continuing basis as required by Section 2(a) of Executive Order 11514. In addition to this general use of this approach in managing USDA programs, the specific procedure for developing environmental statements will be followed where required by the Guidelines or Bulletin No. 71-3.

In implementing this policy we in USDA must examine our procedures and priorities. We have always examined the benefits which we expect to result from our program and project proposals.

We have too seldom formally considered alternative programs and proposals in our decision making programs--including the first alternate of doing nothing at all. Too seldom have we considered the social and economic costs which might result from our proposals, the pollution resulting from the use of chemicals, the burning of crop and forest wastes, and the concentration of very large numbers of livestock in very small areas.

Now we are learning to work together in interdisciplinary systems approaches to problem solving--taking account of all the major parameters and their interactions. That word, interactions, is one that Charles Kellogg has drumed into us year after year--interaction of seed, chemicals, mechanization, soils and water management has doubled our yields, saved our resources, reduced stoop labor and assured abundant harvests--interactions have resulted in pollution of our environment, accelerated migration to our cities and revealed problems we did not anticipate.

Policy is not static. Policy and its implementations--or lack thereof--are challenged. Lately, challenge in the courts has come from public service groups. Three such cases are, in my opinion, highly noteworthy.

The first of these (Environmental Defense Fund et al, versus Ruckelshaus, Administrator of the Environmental Protection Agency) was decided on January 7, 1971, by the United States Court of Appeals. The petitioner sought review by the Court of an order of the Secretary of Agriculture refusing to suspend registration of the pesticide DDT. During the course of the court proceeding, administration of pesticide registration was transferred from USDA to EPA so the Administrator of EPA was substituted for the Secretary of Agriculture as party to the suit.

The court declared that since there is a substantial question about the safety of registered uses of DDT, the Administrator of EPA must initiate cancellation proceedings in order to provide for a Public Hearing. At this public hearing which will begin on August 17, 1971, in Washington, D.C., all persons with relevant information are invited to submit it. The hearing will be conducted as an adversary procedure, just as in Courts.

When the hearing is concluded the Hearing Officer will submit his findings, to be considered by the Administrator of EPA, for the Administrator's determination of whether or not registered uses of DDT are to be cancelled.

This doctrine brings the public into direct participation in the presentation of information to be used in the decision making process. Such opportunities for public participation would appear under these circumstances to be mandatory.

The second case to which I will refer is Environmental Defense Fund et al versus Hardin. In this case, the petitioners sought to enjoin the Secretary of Agriculture from undertaking a cooperative Federal-State program to control the imported fire ant in the southeastern United States.

The United States District Court for the District of Columbia found (EDF et al versus Hardin, Civil Action 2319-70) first, that the "Congress did not intend by the Act (the National Environmental Policy Act of 1969) to relocate or diminish the decision making responsibility currently existing with respect to such programs, but it did intend to make such decision making more responsive, and more responsible."

"Thus in reviewing the Department of Agriculture program under consideration here, the Court will not substitute its judgment for that of the Secretary on the merits of the proposed program but will require that the Secretary comply with the procedural requirements of the National Environmental Policy Act as outlined above."

Significant aspects of the Department of Agriculture research program conducted in connection with the fire ant control program are set forthe in the Court's Findings of Fact. The Court is satisfied that the scope and extent of this research is adequate to comply with the requirements of the Act. The environmental impact statement prepared by the Department, which

forms part of the record of this case, is sufficient in detail and adequate in scope of coverage demanded by the Act.

Thus, through the information and evaluation of that information contained in the environmental impact statement on the imported fire ant statement, the Court found that the Secretary of Agriculture had complied with the requirements of the National Environmental Policy Act of 1969.

The third case to which I will refer is the Calvert Cliffs case. In this case, a citizen's group sought to stop the construction of a nuclear power plant on the shores of the Chesapeake Bay.

The opinion makes a number of points which are relevant to agency procedures to implement Section 102(2)(c):

1. A balancing of economic and environmental costs and benefits is a required part of the 102 process.

> In each individual case, the particular economic and technical benefits of planned action must be assessed and then weighed against the environmental costs...

2. The Section 102 duties are not inherently flexible. They must be complied with to the fullest extent, unless there is a clear conflict of <u>statutory</u> authority.

3. If a decision as to a proposed action subject to NEPA is reached procedurally without individualized consideration and balancing of environmental factors--conducted fully and in good faith--it is the responsibility of the courts to reverse.

There are two other items which I wish to bring to your attention. First, under the Refuse Act of 1899, some operators of large livestock enterprises are required to seek permits from the Corps of Engineers.

EPA and the Corps, in my opinion, have adopted a very moderate course in this instance. Only enterprises with a capacity 1000 steer-equivalent animal units and which have a continuous point effluent discharge are now required to seek permits.

We are all aware that the problem of animal waste management is a very large one. One of the speakers who will follow me will discuss the contributions of the Rural Environmental Assistance Program--to its solution.

Now I wish to bring to your attention some very significant statements in President Nixon's letter transmitting the <u>Second Annual Report of the Council on Environmental Quality</u> to the Congress.

"Our efforts will be more effective if we approach the challenge of the environment with a strong sense of realism. We should not be surprised or disheartened, for example, if some problems grow even more acute in the immediate future.

"We must recognize that the goal of a cleaner environment will not be achieved by rhetoric or moral dedication alone. It will not be cheap or easy and the costs will have to be borne by each citizen, consumer and taxpayer. How clean is clean enough can only be answered in terms of how much we are willing to pay and how soon we seek success. The effects of such decisions on our domestic economic concerns--jobs, prices, foreign competition--require explicit and rigorous analysis to permit us to maintain a healthy economy while we seek a healthy environment. It is essential that we have both. It is simplistic to seek ecological perfection at the cost of bankrupting the very taxpaying enterprises which must pay for the social advances the nation seeks.

"We must develope a realistic sense of what it will cost to achieve our national environmental goals and choose a specific level of goal with an understanding of its costs and benefits. One of the strengths of the accompanying report, in my view, is that it sets out--clearly and candidly--both the costs and the benefits of environmental protection as they are now understood.

"The work of environmental improvement is a task for all our people. It should unite all elements of our society--of all political persuasions and all economic levels--in a great common commitment to a great common goal. The achievement of that goal will challenge the creativity of our science and technology, the enterprise and adaptability of our industry, the responsiveness and the resourcefulness and the capacity of this country to honor those human values upon which the quality of our national life must ultimately depend."

In conclusion, it is Department policy to carry out its programs with full regard for their impact on the environment. When there may be adverse effects on the environment, these will be fully weighed against economic, technical, and environmental benefits expected in making decisions.

The Department will continue to provide information, action, and participation in programs for abatement of pollution. We are expecially concerned with sediment, crop, forest, animal wastes, and agricultural chemicals as pollutants. We are equally concerned with the impact, from whatever source, on agriculture, forestry, and the rural environment.

ASCS-REAP AUTHORIZATIONS AND OBJECTIVES

James Coker

I bring you greetings and best wishes from Ray Hunter. Due to the anticipated announcement of the 1972 REAP, Ray felt he had best stay in Washington to help expedite things if the announcement does come. His interest in this workshop is very keen and I know he would have liked to be here with us.

Conservation and Land Use Program Division - Breakdown of what we do.

Pollution abatement or prevention activities are not new to our agencies. Farmers have been helping to protect the ecology of America for decades--and the conservation cost-sharing program has been helping them do this for many years--in fact, since it began in 1936, the ACP has helped millions of farmers appreciate the need for conservation, and showed them techniques for accomplishing it. ACP has helped keep our soil in place, our waters pure and our landscape more beautiful.

Through the past and present efforts of SCS, ARS, FS, AES and many other federal and state conservation agencies a wealth of technical knowledge regarding pollution and how it can be avoided or controlled has been compiled.

The role of ASCS has been to provide much of the incentive to farmers and ranchers to carry out conservation work through cost-sharing. The Great Plains Conservation Program has also made a notable contribution in its own right through long range planning and cost-sharing.

As all of us know, a new awareness has come about concerning our environment and ways that pollution of our air and water can be corrected or eliminated. One of the outgrowths of this awareness has been the creation of new authorities by way of new laws and agencies in many states and at the national level to deal with pollution. In fact a "Quotable Quote" in the August Readers Digest states "that if we had a penny for every word that has been spoken about pollution in the last two years, we would have enough money to pay for correcting the situation."

I mentioned a moment ago that ASCS provided an incentive to farmers and ranchers to carry out conservation work with cost-sharing under REAP. Some of the new authority which is held by the states and federal agencies provides an added incentive--Stop Pollution or go out of business. This new incentive has proven to be very stimulating to all concerned and has spurred fast action on the part of the farmers as well as in our various agencies.

James Coker, Conservation and Land Use Programs, Agricultural Stabilization and Conservation Service, Washington, D. C.

By law, cost-sharing is limited to conservation measures that have soil and water benefits on farms. New authority has been sought to:

1. Broaden the scope of our activities.

2. Increase the amount of cost-sharing from the $2500 national limit to $5000 (this was included in the appropriation language but did not survive the conference committee).

3. Allow for the treatment of air as well as soil and water (Packwood Bill).

4. Long range planning and cost-sharing.

5. Others.

Review of new pollution abatement practices proposed for the 1972 REAP:

	New Practice	Combination of former practices
I-1	Animal waste storage and diversion facilities	I-1, I-2, I-3
J-1	Sediment retention and water control structures	J-1, C-6, C-7
J-2	Sediment or chemical runoff control measures	C-1 - J-2
J-3	Measures to stabilize a source of sediment	C-2 - J-3
K-1	Disposal of crop, orchard and woodland residues without burning	K-1 and K-2

Description of proposed Practice L-1 (carried out on a pilot basis only)

AUTHORIZATION AND OBJECTIVES OF THE
SCS IN THE FIELD OF SOIL AND
WATER CONSERVATION FOR POLLUTION ABATEMENT

Hollis R. Williams

I appreciate the opportunity to participate in this workshop. Actually it is the fourth one involving Service personnel that I have been privileged to take part in on this important subject--"Pollution Abatement Through Soil and Water Management."

The topic assigned to me deals with the authorizations and objectives of the SCS in the field of soil and water conservation for pollution abatement.

All of us are well aware of the great stress being placed on the need for preservation and improvement of the environment by a large segment of the public and by many in government service.

There can be no doubt that it is a serious problem, and a tremendous effort must be made to stop deterioration of many of our environmental values and improve those that have been damaged.

The problem is that there are too many people being crowded into too little space--and unless things change, it is bound to get worse. Take a look at any one of our cities. Fifteen years ago the suburban area was in woods, fields, and pastures. Now it is covered with homes, shopping centers, and highways. This almost incredible expansion of our population has put a tremendous stress on many of our natural resources. People, and our standard of living, generate problems such as sewage, solid wastes, and water and air pollution. Poorly managed construction operations create serious erosion and sediment problems; open space disappears, and there is a heavy load on that remaining.

The public interest and concern with pollution and the environment is somewhat similar to our rapid population expansion. It seems to have sprung up over night. I think it is a good thing that the public is becoming concerned about the environment, what affects it adversely, and what can and should be done. This is altogether a healthy situation. Aroused public opinion will surely help to solve some of the problems.

All of the rhetoric that has been generated might lead the layman to believe that nothing is being done. This, of course, is far from fact.

Hollis R. Williams, Deputy Administrator for Watersheds, Soil Conservation Service, Washington, D.C.

For more than 35 years the Soil Conservation Service has conducted a constant and successful campaign to preserve and enhance our land and water resources. The contribution of the Service has been enormous in helping to solve overall environmental problems.

In fact, the inception of the Service came about because of an environmental concern--the dust bowl of the early 1930's and a recognition of the great loss annually to the Nation of millions of tons of irreplaceable topsoil caused by uncontrolled erosion on the farms and ranches of America.

Thus was born the Soil Erosion Service as a temporary organization in the U. S. Department of the Interior. In accordance with the provisions of the National Industrial Recovery Act of June 16, 1933 (Public Law 73-67), an allotment of $5 million was made to the Department of the Interior for soil erosion prevention work on public and private lands. Actual operations of the SES began on September 19, 1933, with Dr. Hugh H. Bennett as Director.

Prior to establishment of the Soil Erosion Service, a number of soil erosion experiment stations were set up in USDA under the direction of the Bureau of Chemistry and Soils in cooperation with the Bureau of Agricultural Engineering (Public Law 70-769, February 16, 1929).

On April 27, 1935, Public Law 74-46 was approved which established the Soil Conservation Service as an agency within the USDA, with transfer of functions from the Soil Erosion Service. That act provides our basic authority for technical assistance for conservation operations, soil surveys, snow surveys, and the establishment of plant material centers. The act was broadened with passage of Public Law 74-461 on February 29, 1936, by adding sections under which ACP and the Great Plains programs are carried out. The act was renamed "Soil Conservation and Domestic Allotment Act." The Great Plans Conservation Program became operational with passage of Public Law 84-1021 on August 7, 1956. Since that time the Great Plains Conservation Program has been extended twice, presently running until December 31, 1981.

The Food and Agriculture Act of 1962 (Public Law 87-703) provided the basis for technical assistance in planning RC&D projects and loans assistance, supplementing the authority granted under Public Law 74-46.

In connection with our watershed activities, we have the Flood Control Act of 1944 (Public Law 78-534) which authorized the eleven flood prevention projects, and the Watershed Protection and Flood Prevention Act (Public Law 83-566) which became law on August 4, 1954, and which has been amended several times to broaden its scope.

Language included in the 1971 Agriculture Appropriation Act (Public Law 91-566), approved December 22, 1970, recognized pollution abatement as a proper function of programs within the Department by stating under SCS Conservation Operations, "...measures to conserve soil and water

(including farm irrigation and land drainage and such special measures for soil and water management as may be necessary to prevent floods and the siltation of reservoirs and to control agricultural related pollutants);" (underscoring added).

Also under the Agricultural Conservation Program (now REAP), we find the following language, "...soil and water-conserving practices including related wildlife conserving practices and pollution abatement practices..." (underscoring added).

Quoting from Senate Report No. 92-253 on Department of Agriculture-Environmental and Consumer Protection appropriation bill for fiscal year 1972, as relating to the Rural Environmental Association Program (REAP), "More recently the program has been broadened to provide for the inclusion of related wildlife conserving and pollution abatement practices, with other emphasis on consideration of environmental and ecological values and enduring types of resource-enhancing measures."

With these authorities, embracing all facets of our soil and water conservation activities, we are quite well equipped with the tools necessary to help meet the challenge and goals set forth in the National Environmental Policy Act (Public Law 91-190) which was approved by the President on January 1, 1970.

That act established a national policy for the environment and provided for the establishment of the Council on Environmental Quality. The policy encourages productive and enjoyable harmony between man and his environment, promotes efforts which will prevent or eliminate damage to the environment and stimulate the health and welfare of man, and is intended to enrich the understanding of the ecological systems and natural resources important to the Nation.

National goals established by the act include:

--the assurance of safe, healthful, productive, and esthetically and culturally pleasing surroundings

--the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable consequences

--the preservation of historical, cultural, and natural aspects of our national heritage

--the maintenance of an environment which supports diversity and variety of individual choice

--the achievement of a balance between population and resource use which will permit high standards of living

--the enhancement of the quality of renewable resources and the maximum attainable recycling of depletable resources

Policies, regulations, and laws are to be interpreted and administered in accordance with the policies set forth in the act to the fullest extent possible.

The act further directs the use of an interdisciplinary approach in planning which will insure the integrated use of the natural and social sciences and the environmental design arts.

More specifically, the act requires that for every proposal for legislation or recommendation for other major federal action (such as watershed work plans) we must include a detailed statement describing the environmental impact of the proposed action. Such statement would include a description of adverse effects, alternatives to the proposed action, the relationship between short-term uses and long-term productivity of the environment, and a discussion of irreversible and irretrievable commitments of resources involved in the proposed action. The statement is to accompany the proposal through the interagency review process. The Council on Environmental Quality and the Office of Management and Budget have issued guidelines for the preparation of the detailed statements required. These directives have been further implemented by Secretary's Memorandum 1695, our SCS Environment Memorandum-1, and Handbook Notice 1-17 supplementing instructions in Part 1 of the Watershed Protection Handbook.

In connection with Public Law 91-190, two executive orders have been issued--11507 and 11514. The former, 11507, is substantially a revision of Executive Order 11288, and sets forth the policy for the design, operation, and maintenance of federal facilities in such a manner as to protect and enhance air and water quality. This can affect our plant material centers. So far as Public Law 83-566 is concerned, it has no application other than to require the adherence to state water quality standards where they exist. (This we have been doing for some time.) This decision is based on the premise that PL 566 projects are local federally assisted projects and not federal water resource projects. Also, the situation is not altered in those cases where we agree to carry out the contracting at the request of the sponsors.

Executive Order 11514 is new and implements Public Law 91-190 so far as our programs are concerned. It reaffirms the national environmental goals and describes the responsibilities of federal agencies and of the Council on Environmental Quality. In addition to requiring the continuing evaluation and control of agency activities, it states we must "develop procedures to ensure the fullest practicable provision of timely public information and understanding of federal plans and programs with environ-

mental impact in order to obtain the views of interested parties." Public hearings are required, whenever appropriate, to accomplish this purpose.

The intent of the new act and its implications on our programs are becoming quite clear. The prescribed "interdisciplinary approach" is not new to SCS. We have used it for many years. Nevertheless, we will need to strengthen our expertise in the fields of ecology, landscape architecture, and sanitary engineering. Furthermore, these fields must be recognized on an equal basis with structural engineering and economic analysis as plans are formulated. Alternative courses of action must be developed to achieve project objectives, and the consequences of each must be fully described and evaluated to the extent possible. We need to strive to quantify environmental values and evaluate opportunities we may need to forego to achieve environmental objectives.

The Administrator in his annual message at the Conference of State Conservationists in Lincoln in 1968 stressed the role and impact of SCS activities on the quality of the environment. Some of his statements at that time bear repeating. He said, "We must look at Service work for possible impacts on the quality of the environment. Specifically, we must learn about the possible alternatives for disposal of feedlot and poultry wastes, crop-processing wastes, domestic sewage, garbage, and refuse. We need to know both the utility and the limitation of lagoons, landfills, septic tanks, infiltration ditches, and spray systems for treatment of a variety of wastes. We should use every opportunity, where possible, to promote putting organic wastes back on the land where they originated."

Then he went on to say, "Sediment as a pollutant is attracting more attention. We should obtain and provide more information about the value of our programs to reduce sediment.... With increasing public concern about water quality and sediment as a pollutant, we must keep our own house in order. Some flood-channel designs permit considerable bank erosion before eventually stabilizing.... The small watershed program has shown potential for favorable alteration of the environment. Yet, discontent continues to be expressed by some conservation agencies--particularly those concerned with fish and wildlife. This criticism deserves continuing attention.... Watershed planning must be overall environmental design. No resource can be ignored or slighted."

You are also well aware that the Administrator made a specific charge at the annual conference in 1969 concerning our fish and wildlife interests. This led to a reappraisal in each state of our coordination with state and federal fish and game agencies. Direct action to strengthen working arrangements has been taken whenever the need was indicated. We continue our review of all planned channel improvement not yet constructed in watershed projects.

Although we must remain constantly alert to the environmental influence of proposed actions, we cannot overlook the basic mission of the Soil Conservation Service--the proper management and wise use of all the Nation's natural resources. Resource plans must provide for wise use of all resources, not exploitation of some while enhancing others. Also, plans must be responsive to the objectives of project sponsors. Certainly, we should suggest alternative measures and point out opportunities to protect and improve the environment. But let's not compromise our professional integrity by agreeing to anything less than a comprehensive plan responsive, in a compatible way, to multiple-resource use.

To achieve wise resource use compatible with the national environmental policy, we need to continue to provide even stronger leadership in resource planning than we have in the past. We should coordinate the studies, data input, and recommendations of all agencies assisting with project formulation. We can do no less than assume full responsibility for project planning.

Recognizing the significance of erosion and sediment problems in the pollution fight, we need to give renewed emphasis to the land treatment aspects in watershed project planning and installation.

Although we recognize land treatment is the first increment in project formulation and development, we have taken it for granted too often. We need to point out more forcefully in work plans the beneficial effects of proper land use and treatment in meeting resource goals.

Structural measures still have the major role in providing a satisfactory level of flood protection and water resource development. However, we know that some of our vegetative and mechanical measures provide the most effective means for stabilizing critical sediment source areas and otherwise controlling erosion at the source.

Work plans must be formulated and written to reflect the broader concept--considering the total environment; how the project affects it, both beneficially and adversely. We need to give serious consideration to project selection and formulation, keeping the following points in mind:

a. Flood protection for developed flood plains is a high priority objective. Flood protection to permit higher economic use of flood plains is a low priority objective.

b. Improved drainage of land in agricultural production is a high priority objective, whereas drainage to bring land into production is not looked upon with favor in USDA.

c. It is neither practical or desirable to provide flood protection to all flood plain lands. Don't overlook alternatives--flood plain zoning, floodproofing, or other flood plain management.

d. The Service must be more careful in the future to avoid getting involved in projects or project measures where degradation of the environment is inevitable.

e. Build in all reasonable safeguards for the preservation and protection of fish and wildlife resources consistent with other project needs and objectives. Where damages to fish and wildlife resources are unavoidable, provide for effective mitigation with assurances that such measures will be carried out as planned.

f. We need to take a critical look at our "level of protection" criteria, considering present and future land use, reasonable expectations of changes to be made by landowners, tolerance of crops to depth and duration of flooding, seasonal considerations, containing peak flows within banks versus volume/duration design criteria, etc.

g. Really exhaust the feasibility of utilizing floodwater-retarding storage before resorting to channel alterations. We need to be more sensitive to environmental considerations, particularly in regard to channel improvement. Our current channel review will likely point up some of these shortcomings.

h. We should not be satisfied with just minimizing damage to the environment. Rather, we should be seeking ways to improve it. Our program offers a real potential for accomplishing this objective.

We will need to strengthen our information program as it applies to particular projects. The National Environmental Policy Act of 1969 requires that all viewpoints be heard, in public hearings, if necessary. Public meetings should be held and full use made of the news media. Be sure to describe all project benefits and discuss all environmental effects as fully as possible.

We have made a tremendous contribution toward maintaining and improving the quality of the environment. Perhaps we should do more. It seems to me that two things need to be done. First, we can take greater advantage of the various aspects of the program to improve conditions and, second, we need to inform the public of these things.

A good example is natural beauty. True, we have no authority to do landscaping, but we do use vegetation extensively. I think that many times we would modify a vegetative control program, perhaps by rearrangement of the plantings or by choice of plants to make a structure site much more attractive.

I have a very strong feeling that a farmer, except perhaps for a few hardened violators, would not willingly spoil the environment in which he lives. Nor would he want to contribute to his neighbor's problem. In our 35 years of working with farmers, I think we have found by far the majority

willing to cooperate. Thus, when practices need modification to avoid pollution and this is called to their attention, they will cooperate. There is the carrot and the stick, you know. It is far better that these actions be taken voluntarily than to have them become mandatory.

We need to make a thorough study of all the environmental problems in connection with our planning efforts. For example, are there areas where animals concentrate and runoff is discharged directly into flowing streams? Land treatment measures can be designed to control such problems.

In that connection, we need only to refer to the "Guide to SCS Soil and Water Management Activities that Contribute to the Abatement of Agricultural Related Pollutants," transmitted with Environment Memorandum-4 dated May 7, 1971. That document clearly shows that many of our regular conservation practices have considerable impact and effectiveness in alleviating pollution.

It is by these means that I think we can make a great contribution to the protection of the environment. When problems exist, they should be identified and then discussed at length with the landowner or sponsors. Specific improvement measures should be designed and made a part of the resource plan. It is true that this may take some more time in planning and installing the program. But I believe the results will be well worth the effort.

PHASE IV - PROGRAM IMPLEMENTATION

POLLUTION ABATEMENT:

IMPLEMENTATION THROUGH SERVICE PROGRAMS

Norman A. Berg

The chance to meet with you in discussing pollution abatement through soil and water management--the oldest and the newest Service responsibility--is timely.

By now you have had good discussions about:

--the sources of pollution in this Nation;

--the scope of our pollution problems;

--the relationship between pollutants and the soil and water resources with which we deal every day; and

--the responsibilities, objectives, and policies of several agencies.

You have noted that some of these matters are "old hat" to an SCS professional. You and your fellow conservationists have been dealing with pollution abatement and improvement of environmental quality--directly and indirectly--throughout the history of our organization. In another sense, though, pollution abatement needs a much greater focus in all our work--_we need to get with it_. That is why you are here.

A look at the new SCS guide to pollution abatement measures demonstrates the fact that most of our conservation practices, the way that we have been installing them, have helped alleviate one or more pollution problems. The guide, by the way, is an important reference to policies on how far we can go in what areas of pollution abatement. There are other cases in which conservation practices could be applied in a different place or a different manner in order to do a better job or to do a new job. Some requests for our help have come before we were quite ready with the answers. Some have come before we were quite sure of our authorities. And some have come when we didn't know where to find time to work on them.

Yet, at this workshop, you have learned or been reminded that we have some clearcut authorities in the pollution-abatement arena. We could do a better job with some additional authorities, and we are actively seeking them. _But we can do much more than we have with the authorities we have now. And we must._

You have learned that research is needed in the adaptation of conservation

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Norman A. Berg, Associate Administrator, Soil Conservation Service, Washington, D.C.

practices or the design of new ones to lessen pollution problems. But we can do a better job with the conservation practices that are available to us now. And we must.

The Service for a number of years has taken on even broader assignments, sometimes with a reduced staff, and for a district conservationist to fit them all into a workday is a challenge. The Congress saw fit to boost our appropriation this year so that we could begin to get back to something more than a "skeleton crew" in 3,000 counties. We also hope to add more specialists to back up the field conservationists in work such as solid-waste management and water quality control. But we can do more and better conservation work and pollution abatement with the staff we have now. And we must.

SCS is only one of many agencies involved in pollution abatement. But our responsibility for direct technical assistance on the land gives us an excellent opportunity to play a major role in USDA programs to help reduce agriculture-related pollution of soil, water, and air.

We intend to take a major role in this work.

As you know, the Service has been developing a long-range plan to guide our future efforts--and quite a bit of it dwells on our capabilities and objectives in the pollution abatement field. I know you will give it your careful study as we begin to implement the plan more fully.

Broadly, the long-range plan focuses on the things which need to be done to improve and maintain all the resource management systems that make up our landscape so that they meet quality standards for current and long-term use. It dwells particularly on waste management systems. It gives attention to the effects and benefits that can result from these improvements. And it discusses the kinds of technical action that the Service will need to focus on in the years ahead.

The plan calls for:

1. Broadening our activities in monitoring and inventorying soil and water resources, including their quality;

2. Adjusting our technology to changing conditions and to important concerns such as pollution abatement;

3. Improving our planning assistance to contribute more fully to the planning efforts of one cooperator or the entire Nation; and

4. Working with districts to make soil and water conservation principles and techniques a part of planning and ordinance criteria used by State and local governments and private groups and organizations.

One chapter of the plan zeroes in on breaking up our Service mission into more specific goals and needed future action, such as:

--A massive, country-wide sediment control effort, to consider both on-site and off-site effects.

--Use of effective erosion and sediment control measures at all construction sites.

--Assembly of basic facts on the ability of various kinds of soil and plants to serve for waste-recycling and disposal, and on applicable standards and specifications to guide pollution abatement.

--Development and application of techniques for monitoring and evaluating impacts on environmental quality caused by changes and improvements in the pattern of resource use.

--Assistance to landowners in making waste management an integral part of any conservation plan.

--And working toward effective State and local laws and regulations that provide for the appropriate use of soil and water conservation technology in waste disposal systems.

Another chapter spells out more specific steps the Service will take to meet these and other needs.

In monitoring resource conditions, for example, we plan to develop a comprehensive system that would include soil surveys, snow surveys, sediment surveys, natural resource inventories such as the CNI, and others. Within that system we will work, for example, to get soil surveys done more quickly in areas of high-intensity use or rapid land-use changes. We'll work to get soil facts to the using public within a year of the time the field surveys are completed.

In improving our planning assistance, we'll work to make consideration of soil and water resources a full partner in planning at the national, regional, State, and area levels. We want to give better help to decision makers and citizens at all levels to foresee, identify, and evaluate problems; to establish objectives; to weigh benefits and costs; and to pursue programs of action that enhance orderly growth and quality living.

And in improving our assistance in the all-important area of installation and maintenance, we plan to take these steps:

--Improve present installation methods and develop new ones that save time and money in accelerating conservation application.

--Help sponsors and cooperators develop competent staffs to execute installation.

--Simplify technology for easier use by others in installing conservation treatment measures.

--Undertake studies and experiments to develop the best and most effective means of getting planned measures installed.

--Accelerate efforts by each discipline to simplify the explanation of technical procedures.

--Encourage private enterprise to assume a larger part of the application work and help contractors develop technical staffs to provide layout and quality control services as part of their contract package.

--Encourage colleges, universities, and trade and similar vocational schools to set up courses for training conservation technicians and offer assistance in developing curricula.

--Encourage State and local governments to share in installation services. And,

--Help local governments to organize and train people required for carrying out erosion and sediment control ordinances.

Meeting these and other needs outlined in the long-range plan will call for our best efforts throughout the Service. It will call for some changes in the way we do business in Conservation Operations, Watersheds, RC&D, Great Plains Conservation Program, and every other program activity.

Many of the changes will be brought about by our own desire to do a better job, a more complete job. We always ought to work on total conservation on individual land units or in whole communities. If that means trying something new on a local basis to remove a thorny pollution problem, it may need your consideration even though we might not get involved nationally to any great extent on a specific pollution problem.

We will need to settle on priorities, for pollution abatement work. If some time spent on pollution abatement will bring more public benefit to the total community than say putting in a diversion on a farm, then it's pretty clear where you ought to spend your time. But how much time? In some cases the amount of a DC's time spent on agricultural waste control work is getting disproportionately large although he is doing a whale of a job in this new area. To do the best overall job, perhaps he needs to get himself out of the natural desire to want to follow a project clear through the installation stage. As the long range plan outlines, we may need to get others geared up to take over some stages of conservation jobs. In most cases we will need to set size or dollar limits on pollution abatement work beyond which we ought to recommend calling in private consultants, professional engineers, or others. These limits are being established in most states.

Some other changes in our work will come about as the result of actions outside the Service--such as the Environmental Policy Act that Hollis discussed this morning, the new REAP practices that call for SCS technical backstopping, and a growing compendium of State and local legislation on environmental improvement.

For example, the Virgin Islands has a new Environmental Protection Act under which development plans must be submitted to the local soil conservation district for approval. Maine has a statute that requires clearance of suburban development plans as a check on soil suitability for specific purposes. The Kansas State Highway Department has signed a cooperative agreement with the Service.

These and other sources put new demands or requirements on SCS and district activities.

There will be more coming that will require SCS technical help and we are going to need some funds. As a rule-of-thumb estimate, we probably will require about 10-15 percent for on-site technical help out of every dollar expended on pollution abatement. How much of that we will get will affect how well we can carry out the needed SCS technical help in suitability, design, and supervision of construction, and compliance checks without taking the time away from something else.

All this pollution-abatement and environmental action that is shaping up inside the Service and elsewhere means that we are in the business. As I said, we're only one of many agencies working in the pollution abatement field. Some of the others are just now learning that the Soil Conservation Service exists and has been making meaningful contributions for a long time. We have an opportunity here to develop strong relationships with these agencies that can stand us in good stead in activities that reach beyond any immediate projects or programs. We can help each other do a better job. So maintaining good rapport with other agencies in the field is important. Equally important will be our keeping high standards for the waste management work that we do. We can build a reputation in pollution-abatement and environmental improvement. Whether it is a good one or not depends on the kind of help we give.

Let me repeat what we said in Environmental Memorandum 4 that transmitted the Guide to SCS work in pollution abatement: "Measures to control pollutants often require a high degree of technical skill to plan and apply. For those measures shown in the guide, SCS employees usually are technically competent. They should, however, appreciate the complex nature of this work and be sure they do not extend themselves beyond their actual knowledge. Some of these measures should be undertaken only after adequate consultation with representatives of appropriate local and State agencies. Knowledge of State law and working relationships will help to avoid controversy and meet environmental objectives."

So we need close cooperation. We need high standards. We need to continuously educate ourselves in techniques to do a better job. We need to use our experience in working with landowners and communities to help determine research needs and other sources of needed help in each area of pollution abatement. And we need to help conservation district governing boards "get with it."

We must adapt and apply our knowledge to the urgent need for pollution abatement as we have to all other challenges. It must be part and parcel of working toward our Service's three mission objectives, as stated in the long-range plan:

--Quality in the natural resource base for sustained use;

--Quality in the environment to provide attractive, convenient and satisfying places to live and work; and

--Quality in standards of living based on community improvement and adequate income.

You have quite a challenge. The other speakers this afternoon will give you some valuable guidelines in the specific uses of conservation and waste-management practices. You will need to blend those guidelines with the resource conditions in your area and with the laws and ordinances in your State.

I'm confident that you can and will meet these challenges.

VEGETATION IN POLLUTION ABATEMENT

J. W. Turelle

In discussing vegetation for pollution abatement, one must consider the concept of "diversity." According to some ecologists diversity is the key to protecting the environment.

Among other things, diversity relates to plants, animals, air, water, climate, and man's use of these resources.

Dr. Raymond F. Dasmann of the Conservation Foundation states: "Perhaps the most valuable quality that remains in the human environment is the quality of diversity, the knowledge that one can leave the place where he happens to be and find another that is different."

From this concept of diversity comes a new definition of conservation: "Conservation is the maintenance of a varied environment offering maximum and perpetual freedom of choice to mankind and to its individual members."

Work involving vegetation is certainly diversified. Plants and their development; their interrelationships with other plants, humans, and animals; their establishment and their uses; and their tie-in with other technical, economic, and social phases are all part and parcel of insuring diversity in the environment.

The benefits of plants are generally recognized, but the challenges of Plant Sciences in maintaining a balanced ecosystem are in preventing or controlling soil erosion, reducing or stopping other forms of agricultural pollution, keeping the landscape green, and in general improving the quality of the environment.

Barry Commoner, eminent biologist, once said "Any economic system which hopes to survive must be compatible with the continued operation of the ecosystem."

I believe this statement clearly defines--in a relatively few words--the basic objectives of the business of soil and water conservation, pollution abatement, and upgrading the environment.

We know that soil erosion caused by runoff of water from cropland and grassland is responsible for most of the agricultural pollution of our water resources.

Wind erosion also contributes a significant share of agricultural pollution. It is estimated that of the total sediment produced in this country each year, wind erosion contributes 15 percent.

J. W. Turelle, Chief Agronomist, Plant Sciences Division, Soil Conservation Service, United States Department of Agriculture, Washington, D. C.

The <u>National Handbook of Conservation Practices</u> of SCS lists 119 treatment measures designed to (1) control erosion by wind and water and (2) make the best use of crops, grass, timber, and other organic cover. Forty-eight of these treatment measures are vegetative or cultural; and an additional 34 use vegetation as a supplementary practice. This means that SCS Plant Sciences is involved in 82 of the 119 treatment measures with which we work.

(At this point, Mr. Turelle made a very effective slide presentation. The following paragraphs are selected from his remarks accompanying the slides.)

<u>Cover Crops</u> - Cover crops are needed on highly erosive soils for adequate protection especially in orchards. There are additional advantages for planting cover in orchards such as dust suppression and filtering of pesticides in runoff water.

<u>Stabilizing Critical Areas With Plants</u> - When the earth is denuded by construction in rapidly developing areas, soil erosion is a dangerous by product. Trouble begins when bulldozers strip cover from thousands of acres to make room for new highways, shopping centers, housing developments, etc. This "tearing-up process" is occurring at a rate of 4,000 acres per day.

Construction areas built to modern standards and adequately maintained, have few erosion problems after their completion. The problem is to reduce losses as much as possible during construction. This can be accomplished in part by vegetative means such as making temporary seedings, using vegetative mulches, leaving natural grass cover, protecting existing trees and shrubs, establishing grassed waterways with temporary but rapidly growing plants, and making permanent seedings as rapidly as possible.

<u>Highways and Roads</u> - Highway and road erosion is recognized as one of the principal contributing factors to sedimentation.

We are well aware of the erosion that occurs during and immediately after construction. The soil losses can be enormous. But we are not as well aware of the erosion and sediment damage that occurs from completed secondary roads.

In one state the SCS and the State Highway Commission conducted a road erosion study that showed:

	Miles	Soil Loss T/yr.	Soil Loss T/mile/yr.
Primary 4-lane completed highways	822	3,565	4 approx.
Primary U. S. and State highways	10,844	946,241	87 approx.
Secondary paved roads	33,489	4,217,856	121 approx.
All paved roads	45,195	5,167,662	

Housing, Industrial, and Institutional Developments - Erosion losses from HI&I Developments are often more serious than from roads. Steep slopes, complete removal of vegetation on large areas are often the cause. Vegetation--either temporary or permanent--with engineering practices are definitely needed. Another major reason for severe soil losses on such sites is the failure to prepare a suitable erosion and sediment control plan before construction begins. A plan of this kind will prevent much erosion. SCS through local SCD's are, however, providing more technical assistance with such plans because more and more local governments are requesting erosion and sediment control plans before permits for construction are issued.

Streambanks and Channels - There are about 7 M streambank miles in this country. Actually 8 percent or about 550,000 miles of these banks are undergoing serious erosion problems. It is estimated that $90 M of damage occurs annually from land losses, sediment, and other causes.

Stripmining - The National Surface Mine Law Study recently concluded showed that 2 M acres would benefit from conservation treatment mostly in the form of vegetation, to restore the disturbed areas to productive, stabilized, and attractive conditions. The seriousness of stripmining pollution is indicated by soil losses which can be 1,000 times greater than on adjoining wooded areas. In 10 states, 3 M tons of sulfuric acid from surface mined areas pollute 5,000 miles of streams.

Dunes and Shorelines - Grasses and woody plants, usually supplemented with engineering measures, are used for dune and shoreline stabilization.

Beachgrasses and dunegrasses have been most successful in providing initial control by stilling the sand. These plantings are followed by the growth of woody plants, either through manmade plantings or natural succession.

Gravel Pits and Sanitary Landfills - Gravel pits, after mining operations are completed, and sanitary landfills can be continuous sources of erosion or can be reclaimed for productive agricultural land, recreational areas, or housing, industrial, and institutional developments.

Air Pollution - Plants can be used as weapons against air pollution.

In SCS, our interest in air pollution consists of reducing or eliminating soil dust, smoke from burning residues, and spray from herbicides and other pesticides.

It is estimated that 30 million tons of soil dust float over the United States annually. Dust in suspension is less than 10 percent of the soil moved by wind.

Noise Pollution - If noise is getting you down, perhaps you need to plant some trees and shrubs. Such plants produce a natural sound barrier because they dilute sound energy or loudness.

For the last 30 years the average community sound level has risen one decibel a year which is equal to an eightfold increase in noise. An increase of 10 decibels is equal to doubling loudness of sound.

Normal speech generates 48 decibels; a library, 25; a busy street corner, 80; a barking dog, 92; a beeping horn, 110; a screaming jet more than 140. Sound levels above 50 decibels may be irritable to human beings, and sound levels in excess of 135 decibels may cause pain.

Pesticides, Mineral Salts, Toxic Materials - Restrictions placed on pesticides are creating a demand for alternative methods with Plant Sciences receiving its share of these demands.

Persistence of herbicides on agricultural lands is a problem. Since soil particles absorb pesticide ions, erosion of these particles are directly related to herbicide pollution.

Salinity is a serious problem in the West particularly on irrigated lands. This problem must be overcome by more efficient use of irrigation water; leaching of excess salts; and use of salt-tolerant plants.

Plant Nutrient Pollution - Balance Sheet of N - 1969 (M of tons)[1/]

Inputs from:	Fertilizer N	6.8	
	N fixed by legumes	2.0	
	N fixed (nonsymbiotic)	1.0	
	Barnyard manure	1.0	
	Roots of unharvested crops	2.5	
	Rainfall	1.5	
		14.8	
Removals of N by:			
	Harvested crops	9.5	
	Erosion	3.0	(20%)
	Leaching of soil N	2.0	
	Leaching of fertilizer N	?	
	Denitrification	?	
		14.5	

1/ From Fertilizer Use and Water Quality, October 1970; ARS 41-168.

Most direct way phosphorus moves into water causing pollution is by erosion.

Experiments with cotton and corn in one state showing a soil loss of only 5 tons per acre resulted in a P loss of 10 pounds per acre. Under high erosion, the loss may reach 30 to 50 pounds.

Solid and Liquid Wastes (Vegetative Phases) - Many authorities on the subject claim that disposal of agricultural solid and liquid wastes will ultimately be on the land. One method that has been used to a limited extent for many years, but is now spreading more rapidly, is the use of "living filter systems." These systems are often called "irrigated land disposal systems." There are about 500 canneries in the United States that are using living filter systems for effluent disposal from their products. These systems are very effective with grasses. In one installation, Reed canarygrass (Phalaris arundinacea) yielded between 6 to 8 tons of hay per acre; removed 353 pounds nitrogen in three cuttings; and in 7 years removed 2,733 pounds of nitrogen. Unaccounted nitrogen applied amounted to 14 percent or 47 pounds per acre.

Biology (Wildlife) - Wildlife biology goes hand in hand with other Plant Sciences disciplines.

Most birds and animals find their homes on privately owned land.

On 60 percent of the land area of this country, wildlife coexists with agriculture.

Plants for Conservation and Beautification - SCS Plant Materials Centers are constantly striving to improve our environment with the selection of new plants for erosion control, good land use, wildlife food and cover, and beautification.

Plant Materials Centers evaluate thousands of plants to determine their potential in meeting SCS objectives.

America the Beautiful - Aldo Leopold--the late great ecologist--used to say that "Unless one approaches conservation with an aesthetic as well as an economic perspective, the problem has not even been adequately defined."

So, let's finish with the aesthetic approach as they speak for themselves.

PLANNING AND INSTALLATION OF POLLUTION

ABATEMENT MEASURES - ENGINEERING PRACTICES

R. C. Barnes, Jr.

Pollution abatement is not new to SCS operations. Indirectly we have been doing it in one form or another for the life of the service. Only now in light of new public concern is it beginning to be recognized and receive the attention that it deserves. Part of this, of course, has been our fault in that we may have overlooked these benefits in telling our story.

Any conservation measure that reduces runoff, wind and water erosion, provides better cover for the land and better land use will provide pollution abatement benefits. We now have some new directions in which to move. This is true of both the rural and urban areas.

I will confine my discussion to control of erosion, runoff, and sediment. Charley Fogg will discuss some of the newer aspects of our pollution abatement work as it relates to agricultural wastes.

You know the size of the job as it relates to sediment. Various estimates have been made. We know that it is one of our major pollutants. By volume it is probably one of our greatest. Our geologists tell us that some four billion tons of soil is moved from place by water each year. Some two billion tons are deposited at some other location on land. About two billion tons move into streams and water courses with about one billion tons being deposited in lakes and harbors.

We know that sediment carries with it many other pollutants; plant nutrients, herbicides, pesticides and organic wastes of one sort or another.

Our CNI data shows that despite some 30 years of work some 63 percent of our land is still in need of conservation treatment. We still have a big job to do in the agricultural sector. In addition, we have recognized and are treating sediment sources in urban areas, on roadsides, stream channels, and construction sites.

Based on CNI data you have heard that some 2.6 billion tons of soil moves from place on 437,198 acres of cropland each year.

In the agricultural sector we must continue to modernize conservation systems to better fit farming methods. Only in this way can we gain acceptance of conservation systems. Parallel terraces are a case in point. These were developed to fit the use of larger more powerful and expensive farming equipment. Results in controlling erosion and movement of sediment with parallel terraces have been quite spectacular. ARS reports on studies on one terraced field had 0.4 tons per acre soil loss as compared with 4.7 tons with no treatment. On another, one ton/ac/year as compared with 40 tons/ac/year on

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R. C. Barnes, Jr., Agricultural Engineer, Soil Conservation Service, Washington, D. C.

an unterraced field. This is pollution control in a big way. You probably have similar local data that you can adequately use, perhaps not on parallel terraces but on other erosion control measures. We must tell our story to the public.

Due to effect of herbicides in use with new farming methods we are having problems maintaining grass in waterways. Areas of unfavorable climate have similar problems. In many cases this problem can be overcome by using underground pipe or tile outlets for terraces and diversions. The new corrugated plastic tile works well for this use.

We must pay more attention to planning and installing on-farm road systems. These should be a part of the overall farm plan. When left to the whims of the landowners they can have detrimental effects on the conservation system and can be a source of excess sediment production.

Engineering measures may need to be used to supplement use of vegetation in stabilizing high sediment source areas. Land grading, or smoothing, topsoiling, terraces, diversions, waterways, grade stabilization structures or a combination of these may be needed. If the location is such that adequate treatment cannot be applied, the last resort may be to get below the source to trap runoff and sediment with debris basins.

Stream channels erosion especially on farm channels can be a source of pollution from sediment or other wastes. This is especially true when heavily used for livestock grazing and watering. In many cases, the solution only requires fencing livestock away from the stream, except at controlled watering points. In other cases, the solution may require, grade control, bank stabilization with mechanical means or with vegetation. Proper emphasis must be given to determining the effects of such treatment on other uses such as fish and wildlife.

Most of our engineering practices can be adopted to use in the urban sector and this is receiving increased emphasis.

National standards and specifications for conservation practices have been revised to include recognization of their use in pollution abatement, environmental improvement, and for urban and other land uses. These should be available by September 1. There may still be some measures for which you will have to prepare your own standards.

We need to pay more attention to aesthetics and landscaping in planning and construction of engineering measures. Fitting the practice to the landscape, proper disposal of debris, smoothing, a well finished or polished job, proper vegetation and fencing, should all be considered.

We need to give increased emphasis to control of runoff and erosion in the construction stage on work in which we become involved. We have emphasized this on watershed construction projects, but it applies to other work too. Location of haul roads, stream crossings, protection of borrow and spoil areas from running water, diversion of water, temporary erosion control measures, such as seeding, mulching, and sprays all have a place.

We need to recognize that some of our work can change water temperatures. We need to give more emphasis to measures that offset these effects. Such things as cold water releases, low flow releases, plantings of adapted grasses, shrubs and trees to provide shape and cover have a place. The biologist can be of much assistance in overall planning for these measures.

The use of land and plants will probably have a place in safe disposal of heated water from industrial plants.

Finally in the irrigation field, we are making good use of pumpback systems to recirculate irrigation water heavily loaded with nutrients and herbicides. These involve collector ditches, sumps, pumping equipment and pipelines to collect irrigation tailwater and pump it back through the system. Irrigation systems also have a place in returning wastes from animal production, processing plants and secondary treatment plants. This provides for utilization, recycling, and cleanup and keeps contaminants from our streams and other surface waters.

UTILIZATION OF WASTES BY USE OF VEGETATION

Theodore E. Adams, Jr.

Tested and valuable uses for plant materials are being rediscovered. These uses, "dusted off" and redefined, are finding application in modern conservation.

Greater consideration now is being given to plants and soil as an effective living filter system for purification and reclamation of human, animal and industrial wastes. As publicity concerning the value of soil/plant filters grows, and as protection of the water resource becomes more urgent, requests for information and expertise will grow. Because of its reservoir of plant and soils knowledge, the Soil Conservation Service has a unique opportunity to assist with development of waste disposal systems employing soil/plant filters.

Estimates of the quantity of animal wastes produced annually in the United States range up to 1.8 billion tons. Added to this is the annual production of over 140 million tons of human wastes and quantities of waste from the food processing industry. This represents a disposal problem or a potential resource.

If all sources of human and animal waste are ranked on the basis of quantity of wastes produced, feedlots would first, dairies second and humans third. However, the problem of human waste disposal is complicated by concentration of people and dilution of waste. Seventy-five percent of the population lives on two percent of the land. In addition municipal sewage is primarily water to which wastes have been added. Daily sewage production by 10,000 people is about one million gallons (11).

If all sewage wastes produced by 165 million people (75% of the country's population) were collected for treatment, the quantity might approach 25 billion tons annually. (The weight of sewage is approximately that of water, 8.34 lbs. per gallon.) Because municipal sewage treatment is not universal, this figure is much too high. However, if the figure is 25 percent or as small as 10 percent of 25 billion, it is still greater than all animal wastes produced annually.

The practice of spreading human and animal wastes on land is recorded throughout history. Extensive utilization of the sewage resource by contemporary man through land spreading is a practice that deserves serious consideration. In many other countries various classes of municipal sewage currently are applied to agricultural land, often on a large scale (8).

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municipal sewage currently are applied to agricultural land, often on a large scale (8).

Land spreading of sewage wastes in the United States is not unknown. A survey in 1962 showed that effluent from 401 treatment plants serving 2.7 million people was applied to land (7). Of the plants, 361 serving a population of 2.6 million were in the 17 western states. In the West Region in 1968 only Alaska, Colorado, Montana, Utah and Washington reported no sewage irrigation practiced (4).

In Pleasanton, California, one million gallons or more of secondary effluent from a municipal treatment plant are applied daily to irrigated pasture. Forage present includes several mixtures of grasses and legumes. Ryegrass is common in all fields, but orchardgrass and Hardinggrass are present or dominant in some.

Until recently, the Pleasanton operation was an excellent example of a soil/plant filter. In one year approximately 11 acre-feet of effluent were applied to each acre of the 84 acre pasture. Every day slightly more than 2.5 acre-feet of effluent were applied by sprinkler to about 2.5 acres in daily rotation. Now annual application is 13-14 acre-feet acre or more, and runoff is reported to be taking place. Current daily rates of application are in excess of one acre-foot/acre. With daily movement of sprinklers, the irrigation cycle remains 30-35 days.

Eleven acre-feet/acre is the maximum annual effluent volume the Pleasanton filter can handle under current management and 20 inches of winter rainfall. If application of this effluent is calculated on a weekly basis the rate is a little more than 2.5 inches/acre/week.

The soils present were formed from deep alluvium containing lenses of sand and gravel. These soils are deep to very deep loam and clay loam with moderate to slow permeability. Runoff is slow to very slow. Natural drainage is poor to good, and available water holding capacity is high to very high. In winter the water table is within 20 feet of the surface. It drops to a depth of 30-50 feet in summer.

At minimum, the Pleasanton effluent entering the soil exceeds the supplemental irrigation water requirement by more than 400 percent. The quantity of nutrients contained in 11 acre-feet of effluent also greatly exceeds plan needs. Contained in the effluent percolating through the soil is nearly 400 lbs/acre of nitrogen, over 200 lbs/acre of phosphorus and over 500 lbs/acre of potassium. (The analysis is based on an average of analyses of sewage effluent presented by Kardos (10).)

In the Pleasanton operation three events take place. First the pasture responds to abundant water and nutrients in the effluent (resources are utilized). Continuous growth and uptake of nutrients (recycling of wastes) is assured by year-round grazing - 110-120 head of beef graze continuously except in winter when wet soil limits the number to approxi-

mately 30. Second, excess nutrient sources of particular concern such as nitrates and phosphates not lost as surface runoff are neutralized in the soil profile and present no pollution hazard. This is verified through periodic analysis of percolates by the California Regional Water Quality Control Board. The third event is return of reclaimed water to underground water supplies.

Operation of a soil/plant filter is complex, but the basic features are easily understood. On a living filter such as the Pleasanton pasture the following occurs:

1. Most fecal micro-organisms and biodegradable material are removed during the first 5-10 feet of percolation (2).

2. Nitrogen, phosphorus and potassium, contained in abundance in the effluent, stimulate plant growth. Under optimum conditions most irrigated pasture grasses can utilize 300-400 lbs/acre of nitrogen.

3. Excess nitrates including those converted aerobically from organic sources (approximately 33 percent of total nitrogen) are broken down by anaerobic processes deep in the soil if saturated conditions exist. Denitrification of excess nitrates, the key to prevention of nitrate pollution, requires anaerobic conditions and the presence of organic matter. Anaerobic bacteria feed on organic matter and utilize nitrates as an oxygen source. Necessary organic matter is contained in the effluent. Cyclic application of excess water creates saturated, anaerobic conditions deep in the soil without preventing periodic drying of the surface. (Drying of surface soil is necessary to prevent clogging and loss of infiltration capacity.)

4. Phosphates in excess of plant needs are adsorbed on soil particles. (After 20 years of operation, no saturation of the soil's adsorptive capacity has occurred at Pleasanton.)

5. A substantial portion of three of the four principal mineral salts (potassium, calcium, magnesium and sodium) is taken up by the forage and harvested by livestock. (Excess salts, primarily sodium, have not created a problem at Pleasanton. This may be due, in part, to application of excess water that compensates for any salt accumulation.)

Sewage sludge from the digester at the Pleasanton treatment plant is air dried (sludge is 97 percent moisture) and used by the city and a local country club. The Pleasanton Park Department uses dried sludge as a soil conditioner before planting lawns. Mixed with loam the dried sludge is used by the country club as a top dressing on golf greens. Production of 46,000 gallons/month does not meet demands.

Chicago is using sewage sludge to irrigate and fertilize corn and improve poor quality soil (5). Results of a pilot study are so promising that the entire production of the Metropolitan Sanitary District of Chicago (900 tons per day on a dry basis) may in future be utilized in this manner (18).

In much of the west the best crop for sewage effluent soil/plant filters may be irrigated pasture utilizing a cool-season, perennial, sod forming grass such as reed canarygrass in pure stands. The potential advantages are as follows:

1. Effluent disposal is possible through the year.

2. Forage crops utilize maximum nutrients and water.

3. Uptake of effluent nitrogen is not limited by presence of a nitrogen producing legume.

4. Infiltration is enhanced by the fibrous root system of grass and the retarding effect on runoff produced by sod.

5. Compaction that may occur when livestock graze on wet soils is minimized by sod.

6. Potential human health hazards and objections on aesthetic grounds are avoided by application to a crop not directly consumed by humans. (Some states specify crops on which sewage can be applied and the quality of the sewage product used.)

Maximum utilization of nutrients and water is desired in any living filter. In irrigated pastures a highly productive grass that is tolerant of wet conditions is desirable. Reed canarygrass is suggested for use. This grass has been employed in sewage waste utilization studies (9) (10), and it has demonstrated its productivity and long season of growth over a wide range in latitude.

A team of scientists at Pennsylvania State University has made a detailed study of the use of soil/plant filters for secondary sewage effluent disposal (16). It is suggested (11) that the system should be useable wherever the following conditions exist:

1. "Infiltration capacity of the soil can accommodate irrigation water at all seasons of the year to minimize ponding and runoff and at the same time retain water long enough to allow interaction with plants and microbes."

2. "The soil has a high exchange capacity to temporarily fix and store effluent constituents for use by plants and microbes and to prevent the migration of contaminants to the groundwater reservoir, especially in the winter months when root systems are inactive."

3. "The top layers of soil are permeable to permit vertical drainage of the renovated effluent and thus maintain aerobic conditions."

4. "The soil mantle - the layer between surface and bedrock - is thick enough to insure renovation of the effluent before recharge to the groundwater reservoir."

Since any sewage effluent disposal system must operate on a year-round basis, an irrigation level of two inches a week is currently considered optimum in northern climates (10). This level looks very promising at Penn State based on crop requirements and pollution restrictions and shows that disposal of one million gallons of secondary sewage effluent per day would require 129 acres. For a city of 100,000 people, disposal of similar wastes would require 1,290 acres or approximately two square miles.

Care should be exercised if effluent planned for irrigation is derived from municipal sewage containing substantial industrial wastes. Salts of several elements used in industrial processes may accumulate in soil and become toxic to plants or animals through plant uptake (17). Of concern are the following: molybdenum, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, lithium, nickel, vanadium, zinc, boron and chlorides. This caution is based on known properties of the waste materials. In examples of disposal systems described in the literature, little problem with the wastes has been encountered.

Soil/plant filters can help solve municipal sewage disposal problems and utilize a valuable resource. Other benefits include the following:

1. Water, a finite resource, can be recycled.

2. The system may be cheaper than tertiary chemical treatment.

3. Near urban areas, pastures for effluent disposal can maintain open space and create green belts.

4. The system can help maintain centers of food production close to centers of consumption.

5. The system fits logically into the effort to expand and improve use of irrigated pastures.

6. Pollutants can be kept out of waterways.

7. When considered strictly as a source of irrigation water, effluent compared with deep well irrigation may reduce costs per acre by nearly 45 percent (3).

As previously noted, waste disposal or utilization on cropland is an ancient practice. Probably the most familiar application in the United States is irrigation of cropland with dairy wastes. Generally good results have been achieved using this practice. Increased crop production and degradation of potential pollutants has occurred.

In California several dairies mix liquid manure (drained from barns and holding corrals) with irrigation water (22). Twenty-two million gallons of liquid manure (67.5 ac-ft.) are produced annually by one operation

and utilized on 300 acres. (170 lbs./acre of nitrogen, nearly 15 lbs./acre of phosphorus, and 85 lbs./acre of potassium.) This dairy milkes 435 cows daily on average. Another dairy produces 3.1 million gallons (9.5 ac-ft.) that is applied to 80 acres. (90 lbs./acre of nitrogen, nearly 8 lbs./acre of phosphorus, and 45 lbs./acre of potassium.) The average number of cows miled each day by this operation is 71.

Dairy wastes from a 250 head operation at Oregon State University are applied to pasture (60 ac. total are available) that is primarily "Fawn" tall fescue. (W. H. Billings, personal communication.) Each day approximately 15,000 gallons of wash water and solid wastes are pumped onto the pasture by sprinkler irrigation. It is estimated that 60 tons/acre of manure (including bedding), the waste produced by 4 animals, are applied annually. Contained in this manure is approximately 660 lbs./acre of nitrogen, 130 lbs./acre of phosphorus and 500 lbs./acre of potassium. (The calculated nutrient content is based on manure analyses presented by Morrison (15).)

No problems have resulted from the heavy rate of application. No stand mortality occurs as long as grass blades are not covered. Nitrate poisoning has not occurred from grazing the forage. The only residual observed one year after application appeared to be sawdust bedding.

Experience with heavy rates of dairy waste application on grass/legume pasture by Washington State University contrasts with that just described. In a study west of the Cascades heavy application of dairy manure with up to nine percent solids, coated leaves of legumes in mixed pasture and stifled growth (20). However, ryegrass, the grass constituent, with its narrow leaves and upright growth habit, performed well under the heavy loading. Washington State University currently suggests that wastes from no more than two head of dairy cows be applied to each acre of disposal land. However, scientists at the University believe that, with adequate facilities and good crop management, increased concentration is possible.

It should be noted that manure at Oregon State is high in moisture. The barn is hydraulically cleaned. In the Washington State operation, manure is removed mechanically. The annual volume of liquid manure applied to pasture in the Oregon State operation is nearly 5.5 million gallons (17 ac-ft.).

The problem of disposal or utilization of concentrated manures is particularly severe in the feedlot industry, the largest source of animal manures. Unlike municipal sewage that is primarily water with human waste added, feedlot wastes are primarily manure with some water added. Untreated municipal sewage may have a BOD (Biochemical Oxygen Demand) of 100-400 mg/l. Wastes from a feedlot may have a BOD of from 1,000 mg./l. to over 15,000 mg./l. depending on composition of feed and amount of water added in the handling process (6).

As a potential hazard to the environment, feedlot wastes are of particular concern to the West Region where a great many large operations exist. Of all feedlots with a capacity of 8,000 head or more, 67 percent are located in the West Region (6).

Because a tremendous quantity of concentrated manure is produced on a confined area, in feedlot operations, utilization of wastes must be carefully planned. Land spreading is an obvious solution, but differences in climate in the west require employment of various methods.

One proven method is used by the Monfort Feedlot near Greely, Colorado, an operation that feeds 90,000 head on 320 acres (21). Hundreds of thousands of tons of manure from this feedlot are spread by truck on over 10,000 acres of land growing corn for cattle feed. About 200,000 tons of this corn is chopped for ensilage. The ensilage is mixed with cooked grain and fed to the cattle. This is an excellent example of the recycling of wastes.

Manure from the Monfort operation is cleaned from lots after each feeding period (140 days average) and stockpiled until it is spread on land for sugar beets, small grains and vegetables, as well as corn. Reliable statistics on how much land receives the manure or rates of application are not available. There appears to be nothing systematic about the manure disposal program, but all the manure is returned to the land without a long stockpiling period (Frank G. Viets, personal communication).

At the Pratt Feedlot in Kansas (33,000 head on 220 acres) an average of 10.3 lbs. of dry manure/animal/day are recovered by mechanically scraping pens after each feeding cycle (13). Recovery of dry manure is less than 1,000 lbs./head/year. Manure is stockpiled until corn land on which it is spread is ready to receive it.

In 1969 manure from the Pratt operation contained one percent nitrogen or 20 lbs./ton. Corn yields in 1970 were 23.2 tons from an optimum application of 103 tons of manure (2,060 lbs./acre of nitrogen). (Rates of application ranged up to 320 tons.) However, optimum annual application may be considerably less than 100 tons/acre if effects of each year's application are additive as certain data in this one study indicate.

High nitrate concentrations in forage did not occur from the high rates of nitrogen applied in the Kansas operation. Nitrate levels, usually less than 0.03 percent, were considered no threat to livestock.

At the highest rates of manure application in the Pratt operation, yields were reduced. This was attributed to accumulation of soluble salts, a problem frequently associated with spreading of feedlot manure. In California's Imperial Valley samples of manure contained 8-10 percent soluble salt (13). Management of these salts is the same as that followed by operators confronted with salts already in soil or those added by irrigation water.

The McElhanney Feedlot near Wellton, Arizona, has about 38,000 head on feed and produces about 125-150 tons/day of relatively dry manure. (D. S. Douglas, personal communitcation.) A part of the manure is applied at the rate of 40-60 tons/acre or more to 1,000 acres of irrigated pasture that is mostly bermudagrass for warm season grazing with ryegrass over-seeded for winter grazing.

A breeding herd of about 2,000 head grazes the fertilized pasture. Careful analyses are made of the forage for high nitrate content. No critical levels have been found, and no stock losses attributable to nitrate poisoning have occurred. (This farm operation, independent of the McElhanney Feedlot, obtains 2.5-3 AUM's per acre for a 10 month period.)

Bermudagrass has the ability to use large amounts of nitrogen. Rates of application in excess of those associated with the McElhanney operation have created no problem. In the southeast no nitrate poisoning has resulted from grazing bermudagrass fertilized with chicken litter at the rate of 20 tons/acre/month during the growing season (1). If chicken litter is assumed to contain 40 lbs./ton nitrogen (15) then 5,600 lbs./acre nitrogen are applied during a seven month season.

By way of contrast, heavy rates of chicken litter applied to tall fescue pastures in the southeast have created nitrate poisoning problems. The ARS determined that five tons/acre per month was detrimental (1). When harvested as hay in November, fescue fertilized with 16 tons/acre chicken litter in September can contain 0.6 percent nitrate, enough to induce poisoning and cause grass tetany (21).

Recent research indicates that feedlot manure is almost worthless as a nitrogen source when applied at 80 tons/acre dry weight (Frank G. Viets, personal communication). The intense biological oxygen demand created by the manure causes denitrification of nitrate produced through mineralization. After heavy loading, all nitrate is subjected to denitrification including that present in the soil before manure application.

The optimum manure loading rate for maximum efficiency in crop production is unknown. (Current recommendations generally do not exceed 12 tons/acre.) However, if disposal and denitrification are the objectives high application rates appear to be a solution. (Frank G. Viets, personal communication.)

Classes of animal waste other than those so far discussed pose a potential threat to the environment. Although the magnitude of this threat is relatively small, one class, poultry wastes, should be considered.

The quantity of poultry waste produced annually constitutes slightly more than two percent of all animal manures (6). This small figure does not indicate the local problem often created by attempts to dispose of or utilize the material.

In California successful use is made of chicken manure on vegetables and strawberries, irrigated and dryland pasture and annual grass range. Results from applications on annual range in San Diego County indicated a general average increase of 1,600 lbs./acre of forage for each tone of manure applied (14). This figure represents initial response plus carry-over during three subsequent years. (Annual production of unfertilized range during the years of measurement averaged about 2,300 lbs./acre.) Four tons/acre has been found to be a practical upper limit. Above this rate, forage yield increased only slightly. Chicken manure was found to be just as effective as equivalent rates of inorganic fertilizer. (Dry manure available possesses 70 lbs./ton nitrogen and 40 lbs./ton phosphorus.)

The four-ton rate (10 yds.) considered a practical maximum also is considered a practical minimum. Costs associated with commercial application of the bulky material require an application rate of four tons/acre to make the practice profitable. (R. H. Adolph, personal communication.)

One last class of waste requires consideration. Waste water from food canning operations is an excellent source of nutrients and water for pasture and hay crops.

In Paris, Texas, the Campbell Soup Co. discharges daily from its food processing operations up to 3.6 million gallons of waste water (19). This effluent is applied to a soil with an infiltration rate of 0.10 inch per day. Rates of application are 0.25 inch per day in winter and 0.50 inch per day in summer. A 500 acre site is available for application.

Effluent is purified by microbiological activity (primarily aerobic) and plant uptake of released nutrients during overland flow through reed canarygrass sod growing on terraced slopes possessing a grade of 2-6 percent and a length of 200-300 feet. (It has been determined that slopes of 175 feet would be adequate.) Water is introduced to the system via sprinkler irrigation near the top of each terraced slope. Water moving downhill in a thin sheet is purified including color removal and delivered to a prepared waterway at the top of the next terrace. It then flows away to a receiving stream.

The Campbell Soup system is 99 percent efficient in removing BOD, and it reduces nitrogen and phosphorus content by 90 percent. (In one million gallons of waste water there is 145 lbs. of nitrogen and 64 lbs. of phosphorus.) Wastes originally 750-850 ppm BOD are reduced to 2.5-10 ppm BOD, far below minimum Texas requirements. This efficiency continues in winter when as much as two feet of ice accumulates beneath sprinklers. Microorganism respiration slows down as temperature decreases but the number of organisms increases. As a result, a constant level of mass activity is maintained.

Grass on the terraced slopes serves several functions. First, it protects the soil surface from erosion and retards water flow. Next, it provides a protected habitat for microorganisms and a vast surface area for adsorption of impurities in the effluent. Finally, when cut periodically for hay, it becomes a valuable cash crop and provides an effective means for reclaiming nutrients released by decomposing organic matter.

A great deal of "fail-safe" capacity is built into the system. If a single terraced slope is overloaded or suffers a mechanical failure, the effluent continues in the long terraces and waterways before reaching the receiving stream.

The system has the outstanding capability of handling extremes of operation. It can handle surges or shock loads during peak operating periods or tolerate a long shutdown followed by immediate restart. Excellent results are produced in both situations.

There are indications that while mineral salts have increased greatly in the filter fields the rate of increase has declined. To date accumulations are not critical.

The Paris, Texas, operation demonstrates the effectiveness of an overland flow filtration system for reclamation of organic wastes with a low nitrate concentration. When infiltration is limited, employment of living filters can be considered if surface drainage and waste composition permit.

The value of reed canarygrass, a northern species, was demonstrated. In northeast Texas the grass grew well when supplied with sufficient water. Hay production in 1968 from three cuttings of established stands of reed canarygrass yielded 3.65 tons per acre. The hay had a high nutritional value ranging up to 23 percent crude protein. It contained 62 lbs./ton of nitrogen (over 226 lbs. total) and 10 lbs./ton of phosphorus (over 36 lbs. total). The mineral content was nearly double that found in other good quality hay.

Palatability tests in which reed canarygrass hay was compared to good quality bermudagrass and johnsongrass hay, Hay Grazer (a hybrid resembling millet) and Sericea (a legume) established the generally superior palatability (and market value) of reed canarygrass from the Paris disposal system.

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ANIMAL AND POULTRY WASTE MANAGEMENT

Charles E. Fogg

A. MAGNITUDE OF PROBLEM

It is estimated that over one and three-quarter billion tons of livestock and poultry manure (feces and urine) are produced in the United States annually. While there is no doubt that a portion of these wastes contribute to degradation of the environment, including pollution of surface and ground waters, the major sources of such pollution are concentrated production areas.

Estimates of manure produced through concentrated production methods vary widely. The numbers of livestock and poultry produced under concentrated conditions can serve as a basis for estimating volumes of manure which have the highest potential for degradation of the environment. This, in turn, can be useful in determining areas of need for improved waste management systems.

USDA, Statistical Reporting Service (SRS) publication LvGn 1 (71), 1971 Livestock and Poultry Inventory reports that there are 114,568,000 dairy and beef cattle, 19,560,000 sheep and lambs, 67,540,000 hogs and pigs, and 450,246,000 chickens and turkeys on farms and ranches across the country. There are also about 459,280,000 broilers being raised at this time.

Table 1, Livestock and Poultry Inventory - 1971, shows numbers of cattle, sheep and lambs, hogs and pigs, chickens and turkeys, and broilers on farms and ranches.

Estimates of manure produced per head by livestock and poultry vary widely. Variations are due to climate, type of feed, production methods, and measurement techniques. The following tabulation is the author's estimate of manure production across the country:

Dairy Cattle - 21,394,000	@ 100#/day =	390,400,000	Tons/Yr.
Beef Cattle - 93,174,000	@ 75#/day =	1,275,300,000	Tons/Yr.
Total Cattle - 114,568,000		1,665,700,000	Tons/Yr.
Sheep and Lambs - 19,560,000	@ 4.0#/day =	14,300,000	Tons/Yr.
Hogs and Pigs - 67,540,000	@ 8.5#/day =	104,800,000	Tons/Yr.
Poultry, Turkeys and Broilers - 909,526,000	@ 0.25#/day =	41,500,000	Tons/Yr.
		1,826,300,000	Tons/Yr.

By comparison, the entire population of the nation, over 200,000,000 people, produces about 142,000,000 tons of feces and urine per year.

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In considering pollution from cattle, concentrated beef feedlot and dairy operations have the greatest potential. Cattle on open range or widely dispersed in pastures deposit their wastes on the land with generally minimal adverse effect on the environment. According to USDA, SRS publication MtAn 2-1 (1-71), Cattle on Feed, there are only 12,762,000 head of cattle on feedlots in the 39 states producing the bulk of cattle on feed. It is also estimated that there are about 21,390,000 dairy cattle across the country. It must also be recognized that many beef feeding and dairy operations utilize good waste management systems.

Most sheep and lambs are raised under conditions which have little adverse effect on the environment. There are, of course, isolated instances where inadequate management results in pollution problems, but these probably involve less than one percent of the total sheep and lambs produced.

On the other hand, most swine and poultry operations are carried out with concentrated production methods. Therefore, such operations have a relatively high potential for pollution of air, water and soil unless good waste management is practiced.

Manure produced by broilers is generally handled dry and spread on the land. Only a portion of this manure can be considered a serious pollution problem as land spreading systems are generally satisfactory.

Table 2, Cattle Feedlots - 1970, shows number of cattle on feed as of January 1, 1971, and number of feedlots of varying capacities in the West Region. This table can be used as a guide to areas where pollution from beef feedlots may have comparatively high potential.

In considering dairy cattle, many producers already have adequate waste management systems. Many dairy farm operators also confine their cows for only a portion of the time - some for only milking and feeding periods - and put them out to pasture for the remainder of the time. Many dairy farms provide sufficient area to preclude significant environmental degradation during pasturing. In colder climates dairy cattle are pastured only during mild, snow-free periods. Therefore, the proportion of dairy manure considered as having a significant potential for pollution will vary across the country.

Nationally, it is estimated that about 40% of manure produced by dairy cattle can be considered as having a relatively high potential for degradation of the environment, including pollution of surface and ground waters. Similar estimates can be made for the various states and regions across the country.

It appears reasonable to estimate that 80% of swine and poultry operations and 50% of broiler operations produce manure under conditions which merit careful pollution control considerations.

The following is a tabulation of estimated volumes of manure having a relatively high potential for degradation of the environment:

Dairy Cattle	
0.4 x 21,394,000 @ 100#/day =	156,180,000 Tons/Yr.
Beef Cattle on Feed	
12,762,000 @ 75#/day =	174,680,000 Tons/Yr.
Hogs and Pigs	
0.8 x 67,540,000 @ 8.5#/day =	83,820,000 Tons/Yr.
Chickens and Turkeys	
0.8 x 450,246,000 @ 0.25#/day =	16,430,000 Tons/Yr.
Broilers	
0.5 x 459,280,000 @ 0.25#/day =	10,480,000 Tons/Yr.
Total	441,590,000 Tons/Yr.

It should be kept in mind that only a small portion of the pollutants in the foregoing tabulation of volumes of manure actually reach surface or ground waters. Runoff and infiltration from concentrated livestock areas remove only a fraction of the pollutants in manure. Unless manure is dumped directly into watercourses, only a small percentage of the pollutants associated with manure from other livestock and poultry operations actually reach surface or ground waters.

The foregoing estimates of livestock and poultry manure volumes having a relatively high potential for degradation of the environment should be useful in assessing the general magnitude of animal waste management problems facing the country by regions and states. Local climate, production methods, feed, and waste management practices have a substantial effect on the relative magnitude of pollutional problems in various areas of the country.

B. COMPOSITION OF MANURE

It is dangerous to try to tabulate "average" manure production per animal as actual production figures vary so widely. In dealing with specific animal waste problems local data or on-site measurements should be utilized.

Table 3, Daily Production and Composition of Animal Manure, lists estimates of daily production of manure (feces and urine) as well as BOD_5, COD, Total Solids, Volatile Solids, Nitrogen, Phosphorus, and Potassium. These estimates are composites of the various references cited and reflect the author's judgment of average figures, Comparable figures for people are also included. In developing estimates of manure production, it is more accurate to base them on total weight of animals or poultry than to go strictly by number of head.

C. POLLUTIONAL CONSIDERATIONS

It would be a mistake to deny that animal manure is a substantial polluter of the environment--particularly of our surface and ground water resources. As the foregoing tables indicate, animal production of BOD, COD, Total

Solids, Nitrogen, Phosphorous and Potassium exceeds human production by many times. Even if we assume that only one-quarter of these animal wastes are produced under conditions having a high potential for degradation of the environment, they still far exceed those of the human population.

BOD - Biochemical Oxygen Demand

BOD is a quantitative measure of the free oxygen required to oxidize readily available organic matter in wastes. Its determination is based on incubation of a mixture of waste and water under aerobic conditions for a specified period of time--5 days generally being standard--and measurement of the oxygen consumed.

Until very recently, BOD has been the primary measure of pollution by domestic sewage. The degree of treatment achieved by primary and secondary sewage treatment plants has usually been determined by the percent reduction of BOD.

The nature of animal wastes differs somewhat from that of humans. The manure from ruminants such as cattle, has a different composition from manure produced by single stomached species. It has been established that lon term BOD--say 30-day BOD--is many times as great as the 5-day BOD. It appears that 30-day BOD or COD, Chemical Oxygen Demand, may be more indicative of total oxygen requirements of animal wastes.

The pollutional effect of BOD is to reduce or deplete dissolved oxygen in waters of our streams and lakes. Dissolved oxygen above a certain minimum level must be present in surface waters to support fish and other aquatic life. Septic conditions prevail in water without dissolved oxygen.

COD - Chemical Oxygen Demand

COD is a measure of the oxygen required to reduce all oxidizable material in wastes. It is evaluated chemically through use of sulphuric acid and potassium dichromate to determine the quantity of oxygen required for total oxidation.

The COD of animal manures are generally several times as great as their 5-day BOD. COD probably more nearly indicates long term oxygen requirements of these wastes. The pollutional effect of COD is the same as that of BOD. Wastes with high COD also tend to add to the bottom deposits of sludges which constitute a continuous benthal demand on dissolved oxygen in the water above.

Total Solids

Occasionally referred to as TS, total solids of a waste is the residue remaining when water is evaporated away from a sample of the wastes and the remaining material is dried by heating at about 103°C.

The pollutional effect is the depletion of dissoved oxygen in surface waters in oxidation of the oxidizable portion of the total solids.

poultry production. Such systems must be developed with the cooperation of local, state, and federal health and regulatory agencies to insure compliance with health and water quality standards.

Research has clearly indicated that conventional waste treatment plants for domestic sewage cannot be readily adapted for practical treatment of animal and poultry manure. The reasons for this are varied. While municipal sewage is primarily water with man's wastes added, animal wastes are primarily manure with small amounts of water added. The resulting mixture of manure and water is extremely potent when compared to municipal sewage.

Untreated municipal sewage may have a BOD of about 100 to 400 mg/l. Runoff from a cattle feedlot may have a BOD of from 1000 mg/l to over 15,000 mg/l. Liquid manure from dairy operations may have a BOD of 2,300 to 24,000 mg/l with an average of around 8,500 mg/l. Manure from a swine operation will have a BOD of 8,000 to 80,000 mg/l, averaging 30,000 mg/l. Liquid poultry manure may have a BOD of 16,000 to 100,000 mg/l, averaging about 45,000 mg/l. Strength of the liquid manure varies due to feed and amount of water added in the handling process.

From the foregoing it can be seen that it is not economically feasible to dilute the wastes from most large scale operations to be similar to municipal wastes in strength. In addition the content of animal manure, particularly beef and dairy cattle is not readily amenable to rapid degradation by conventional municipal waste treatment plants. Nor would conventional primary and secondary treatment remove sufficient nutrients from animal wastes to prevent serious degradation of receiving waters.

Animal wastes are a natural resource which should be utilized. It appears at this time that returning such wastes to the land offers the best hope in most cases for satisfactory waste management. The BOD is satisfied at or near the surface and the nutrients are utilized by plants. Organic components improve soil structure.

Returning animal wastes to the land without degrading soil or water accomplishes the desirable objective of recycling. It is the oldest method of waste management known to man. To do this successfully with modern concentrated production methods requires careful evaluation of soils and plant cover. The capability of the various soils and plants to accept and safely assimilate such wastes is an important basis for design of waste management systems. This, of course, is true for all wastes applied to the land - not just livestock and poultry wastes.

Nitrogen is probably the most common limiting constituent of animal and poultry wastes with respect to amounts which may be applied to land and cover without adverse effect on ground water supplies. Plant growth uses nitrogen. The amount of nitrogen that can safely be applied to crops depends on available nitrogen in the soil and amount required for plant growth. This may vary from around 130 to 300 pounds of nitrogen per acre per year. Excess nitrogen, over and above that used by the crop and tied up by the soil, is converted to nitrates and can contribute to ground water pollution.

Volatile Solids

Normally referred to as VS, volatile solids are the portion of total solids which is driven off as volatile gases when heated to 600°C for one hour. Volatile solids normally represent 60 to 85 percent of total solids. They are the fraction of total solids contributing to pollution and oxygen depletion of surface waters.

The volatile solids of animal manures is probably a better measure than BOD of the pollutional potential of such wastes.

Nitrogen

All animal as well as human wastes contain nitrogen. Generally nitrogen in animal manure is in the form of ammonia, nitrites or nitrates. When allowed to oxidize, the nitrogen will generally be converted to the highly stable nitrate form which is soluble in water. Nitrates are readily leached through the soil profile.

Water containing excess nitrate (over 45 mg/l nitrate ion) is considered dangerous for human consumption. Serious and occasionally fatal poisonings of infants have occurred as a result of drinking water with excess nitrates. Cattle poisoning from drinking water with high nitrate content has also been reported.

Nitrogen is a basic nutrient required in the process of eutrophication of streams and lakes. Highly enriched water promotes excessive algae growth and highly undesirable water conditions.

The pollutional effect of nitrogen is to add toxic nitrates to surface and ground waters and to contribute to eutrophication of our streams and lakes.

Phosphorus

Phosphorus is also a constituent of animal and human wastes. It, like nitrogen, is a basic nutrient required in the process of eutrophication. Unlike nitrogen, phosphorus in solution is readily adsorbed by the clay particles of soil and leaching of this nutrient to the ground water is more easily controlled.

Water pollution by phosphorus is generally caused by direct runoff of water or wastes containing the nutrient to a stream or lake or by soil particles containing phosphorus being eroded and carried to such bodies of water.

Potassium

Potassium is a nutrient necessary to the growth of plants. It is not generally considered a pollutant to surface or ground water and it is not a controlling nutrient in the process of eutrophication.

D. WASTE MANAGEMENT SYSTEMS

Livestock waste management systems for protection of land, air, and water must be made an integral part of conservation plans for livestock and

Waste management systems must be tailored to the needs of individual owners or operators. They must provide for utilizing or disposing of livestock and poultry wastes without polluting ground or surface waters and without objectionable odors. A good system (a) diverts clean water away from areas where wastes are concentrated, (b) provides controlled drainage of runoff from such areas, (c) prevents leaching of contaminants into groundwater, (d) collects polluted runoff, and (e) utilizes, treats or safely disposes of collected runoff. Solid manure should be removed and stockpiled, if necessary, until it can be safely spread on the land.

Liquid manure resulting from many dairy, swine, and poultry operations as well as polluted runoff from concentrated livestock areas can often be disposed of by a water spreading or irrigation system using the soil and plant cover for treatment. Aerobic and anaerobic lagoons, used singularly or in combination, often are employed to provide at least partial treatment of liquid manure wastes. The effluent from these lagoons seldom meets water quality standards, precluding discharge to streams or waterways. Usually the effluent is disposed of by being applied to the land.

Livestock waste management systems utilize a number of old proven soil and water conservation practices.

Diversions

Use of diversions or dikes is the most common method for diverting unpolluted water from concentrated livestock areas. They are usually designed to safely pass the runoff to be expected from a 10-year frequency, 24-hour storm. Other criteria may be used in unusual circumstances or where hazard from over-topping dictates. Diversions are carried to grassed waterways or other safe outlets.

Grading

The concentrated livestock area should be properly graded to promote surface drainage and lot drying. Individual compartments or lots should drain to an outlet rather than into adjacent lots. A minimum grade of about one percent is desirable for good surface drainage.

Below the concentrated livestock area, polluted runoff should be intercepted and directed to spreading areas or holding ponds. Once again, diversions can serve as interceptors. They can also serve as settling areas for removal of solids carried in the runoff if velocity of flow is held to 1.0 foot per second or less.

Debris Basins

A debris basin may also be used to settle solids. The storage capacity and principal spillway capacity of a debris basin should be such as to provide for 24-hour to 72-hour drawdown. The basin should be empty between runoff periods.

Settled solids in intercepting diversions and debris basins must be removed periodically and handled separately. These solids can be disposed of in the

same way as solid manure.

Holding Ponds

A holding poind is used to temporarily store runoff from concentrated livestock areas. It is usually designed to follow a settling area and to hold the runoff to be expected from a 10-year, 24-hour storm. Site conditions or local and state regulations may require that other criteria be used for design. Liquid in the holding pond should be disposed of soon after a runoff event to maintain the original capacity. Usually, the recommended emptying time is not more than two weeks, but it varies depending on the likelihood of recurrence of a significant runoff-producing storm. The most common methods for emptying the holding pond are through water-spreading or irrigation systems.

Holding Tanks

Holding tanks of reinforced concrete or other durable material are often constructed to store liquid manure from housed livestock and poultry operations. Their prime purpose is to temporarily store manure for land spreading when conditions are favorable.

The amount of storage to be provided depends on how long a period the manure must be accumulated to insure spreading under favorable conditions. A 1200 to 1400 lb. cow produces about 1.56 cubic feet of feces and urine per day, a 150 lb. pig about 0.14 cubic feet per day, and 1000 4 to 5 lb. chickens about 4 cubic feet per day. Wash water must be added to the foregoing to arrive at storage required per day in the holding tank. Storage for two to six months waste production is usually provided depending on severity of climate as it affects land spreading. Occasionally certain cropping operations will make it desirable to spread liquid manure only at certain times of the year or when labor requirements are more easily met. Determination of waste volume per day should be based on actual waste production for the individual enterprise.

Special liquid waste handling equipment is necessary to remove the waste from the holding tank and carry it to selected areas for spreading. Commercial agitators, pumps, and liquid manure tanks (honey wagons) are available. Sprinkler irrigation systems can be designed and operated to utilize or safely dispose of sufficiently diluted liquid wastes.

Land Spreading

Land spreading is probably the least complicated method of animal waste utilization for many farm operations with primarily solid manure to dispose of. When applied within reasonable limits at proper times to avoid being carried away by runoff, it will generally benefit crops, improve the soil and prevent pollution of surface and ground waters.

BOD and COD are satisfied by biological degradation at or near the ground surface. Nitrogen, phosphorus and potassium are utilized by the plants. Phosphorus is also adsorbed by clay particles of the soil. Coliform bacteria, indicators of possible pathogenic organisms in water, are filtered out or die out within the first few feet of soil.

Some areas of caution in land spreading of solid manure are:

Do not spread on snow or frozen ground.

Avoid spreading when rainfall is expected.

Apply at rates consistent with soils and crops involved but generally not exceeding 8 to 10 tons per acre per year on cropland.

Disposal Lagoons

A lagoon is a pond of water plus wastes flushed from animal production operations. Lagoons are designed to decompose or digest waste material through bacterial action.

Aerobic lagoons are designed and operated to maintain dissolved oxygen in the water at all times. Aerobic bacteria produce water and carbon dioxide and convert nitrogen from proteins into nitrites, nitrates and some free nitrogen when consuming the wastes. Aerobic lagoons are generally designed to be 5 feet or less in depth to promote algae growth. Algae, in the presence of sunlight, produces oxygen which augments the oxygen naturally supplied from the air to the lagoon surface.

With the relatively high oxygen requirements to reduce animal wastes, a large surface area of lagoon is required to maintain aerobic conditions. In northern climates where ice may limit sunlight for growth of algae and cold temperatures may restrict bacterial action an aerobic lagoon may just serve as a holding pond until warm weather returns. Even a properly designed and operated aerobic lagoon can be expected to give off odors at the time ice breaks up in the spring.

Design of aerobic lagoons is generally based on BOD loading and surface area of lagoon. Recommended loadings vary from state to state and are usually based on experience in treating municipal sewage. Aerobic lagoons in warm climates can be loaded more heavily than those in cold climates and still maintain dissolved oxygen in the water. Loadings of 10 to 80 pounds of BOD_5 daily per acre of lagoon is the normal range of loading where aerobic conditions can expect to be maintained. Fifteen to 35 pounds of BOD_5 per day per acre is more common.

Much more needs to be learned about the use of aerobic lagoons in treating animal wastes. It is quite probable that the long term BOD rather than the 5-day BOD of animal wastes may evolve as the basis of design. The long term BOD of animal wastes--say 30-day BOD--will be two to five times the 5-day BOD. It appears to be about equal to the volatile solids of animal wastes. This factor may well be the reason for failure of many aerobic lagoons in treating animal wastes.

While some states allow discharge of aerobic animal waste lagoon effluents to streams it is generally not a very desirable practice. It is true that the 5-day BOD may be reduced by over 90 percent and that the effluent water is high in dissolved oxygen. However, the remaining 10 percent BOD_5 can be very high in terms of mg/l when it is remembered that the original wastes probably contained anywhere from 1,000 to as much as 100,000 mg/l BOD_5. Even with 90% BOD_5 reduction the lagoon effluent may have a concentration of 100 to 10,000 mg/l which will generally be unsuitable for discharge to receiving waters. The lagoon liquid also contains algae. These algae will eventually die and exert an oxygen demand on the receiving stream. This demand may exceed that of the original wastes treated in the lagoon. Although methods for harvesting and utilizing algae are being studied, no practical large scale method has yet been developed.

Use of aerobic lagoons to treat animal wastes will probably be very limited due to the large surface areas required. It is possible that aerated lagoons may play an increasing role in treating animal wastes. Surface aerators are the most common method for aerating such lagoons. If power is not reliable standby equipment must be provided as septic conditions will develop rapidly once aeration stops.

The oxidation ditch is also becoming popular as an aerobic method of treating animal wastes. It is a race track shaped ditch which has a revolving drum-like beater which keeps the liquid circulating around the race trach ditch and supplies air to the liquid. It is not without problems. Extensive foaming and bad odors have been experienced during the start-up period. Once again standby equipment must be provided if power is not reliable.

Anaerobic lagoons are designed and operated to exclude dissolved oxygen in the water. Anaerobic bacteria disgest the waste and gases such as methane, carbon dioxide and hydrogen sulfide are released. These lagoons give off odors--particularly if much hydrogen sulfide is produced. Fortunately, in a properly designed and operated anaerobic lagoon, methane and carbon dioxide are the primary gases produced and they are comparatively odorless.

Anaerobic lagoons are constructed to have liquid depths greater than five feet. Actually, the deeper they are the better they operate. Current practice is to design these lagoons on a BOD or a volatile solids loading and volume basis. From 1 to 4 pounds of BOD_5 daily per 1,000 cu. ft. of lagoon volume is a normal basis of design. Greater depths require less surface area to give off odors.

Many authorities suggest that volatile solids may be the best design basis. Lagoon design on the basis of 3 to 5 pounds of volatile solids per day per 1,000 cf for swine lagoons and poultry lagoons and 7 to 15 pounds of volatile solids per day per 1,000 cf for cattle lagoons appears reasonable.

There will be considerable build up of sludge in anaerobic lagoons. T. L. Willrich of Iowa State University found that for every 20 pounds of volatile solids entering a swine lagoon one cubic foot of sludge would be produced each year by a 135 pound hog. Little information is available on the anticipated sludge buildup in poultry and cattle lagoons.

Anaerobic lagoons operate best at temperatures of 70° to 130°F. There is little activity at temperatures below 45°. Loading of a new lagoon should be done in the spring or early summer so that desirable bacteria have as much time as possible to become established before cold weather sets in. This reduces the chances of extensive periods of foul odors. A properly operating anaerobic lagoon should have a pH above 7.0. Odor problems become more intense with a lower pH. A lime slurry or sodium bicarbonate has been used to raise pH and reduce odor problems.

Anaerobic lagoons do not provide complete treatment of animal wastes. Effluent is not suitable for discharge to streams. Most of the BOD and COD reduction in anaerobic lagoons results from the settling out of solids and biological degradation of organic matter. The studies by Willrich indicated that with a detention time of 54 days there was 75 to 80 percent removal of total solids, 85 to 90 percent of the volatile solids and COD, 60 to 70 percent of the BOD, and 45 to 50 percent of the nitrogen.

Use of two or more lagoons in series is gaining favor in the treatment of animal manures. The first is designed as an anaerobic lagoon and the second as an aerobic lagoon. Larger systems could utilize two or more anaerobic and aerobic lagoons. There has been some success in use of surface aerators in anaerobic lagoons for odor control.

Some precautions to keep in mind relative to design and operation of both anaerobic and aerobic lagoons are --

Design to minimize groundwater pollution. This involves keeping the lagoon above the groundwater table and constructing only in soils of low permeability or providing for sealing.

Load as frequently and uniformly as possible. This is particularly important for successful aerobic lagoons.

Load initially in the spring or early summer to allow maximum growth of bacteria before the colder inactive period arrives.

Allow for possible future expansion.

Allow ample space for sludge and plan to remove it before it encroaches on the volume needed for satisfactory biological treatment.

Methane gas, produced in anaerobic lagoons, is explosive. Do not allow its accumulation in enclosed areas.

E. CONCLUSION

Livestock and poultry waste management systems must become an integral part of soil and water conservation plans prepared by the Soil Conservation Service. Such systems are vital to the protection of soil, air and water resources.

It is imperative that a complete waste management system be planned before single practice components are installed. Such complete planning will preclude the installation of a single practice only to find later that it is not a logical part of a sound overall waste management system. Or even worse, find that the farm or ranch enterprise is unable, financially or physically, to meet the overall requirements of air and water quality standards.

All waste management practices must be developed with the cooperation of state agricultural experiment stations and regulatory agencies to insure compliance with available local experience, data, and regulations. All waste management system designs should be reviewed and approved by appropriate state air and water pollution control agencies prior to installation.

It should be recognized that current and future research and experience may dictate substantial revision of present waste management standards and design criteria. In the meantime we should do the best job possible with existing knowledge and reduce insults on the environment to the fullest extent possible.

Table 1
Livestock and Poultry Inventory - 1971
West Region

States	Cattle[1] Dairy[2]	Cattle[1] Beef[2]	Cattle[1] Total[1]	Sheep[1] and Lambs	Hogs[1] and Pigs	Chickens[1] and Turkeys	Broilers[3]
	1000 head						
Alaska	3	6	9	27	1.1	26	
Arizona	77	1212	1289	506	79	4/1373	
California	1269	3502	4771	1264	165	56092	13370
Colorado	200	3316	3516	1229	352	2135	
Hawaii	24	225	249	---	58	1370	
Idaho	288	1447	1735	773	171	4/1139	
Montana	72	3032	3104	1142	221	4/1400	
Nevada	27	630	657	206	13	23	
New Mexico	55	1317	1372	799	60	4/1340	
Oregon	201	1408	1609	479	122	3497	2333
Utah	137	703	840	1058	59	1880	
Washington	301	984	1285	144	96	6390	3170
Wyoming	28	1433	1461	1734	38	4/ 197	
Total	2682	19215	21897	9361	1435.1	76862	18873
TOTAL - 50 STATES	21394	93174	114568	19560.3	67540.6	449111	459280
						Other States: Turkeys	
						1135	
						450246	

1/ From USDA, SRS Publication Lv Gn 1(71). As of 1/1/71 except for hogs and pigs which is of 12/1/70.
2/ Proportion based on Tabulation for January 1, 1970
3/ From USDA, SRS Publication Pou 2-7(71) 8/52 of total year production (to reflect average broilers on hand at one time)
4/ Excludes turkeys which are included in "other states" at end of table.

Table 2
Cattle Feedlots - 1970 1/
(West Region Primary Feeding States)

States	Cattle on feed (1000 head)	Feedlot Capacity in Head[2] Under 1000	1000 to 1999	2000 to 3999	4000 to 7999	8000 to 15999	16000 to 31999	32000 and over	Total Feedlots
		Number of Feedlots							
Arizona	524	8	7	8	13	11	8	6	61
California	1001	153	67	76	52	47	20	10	425
Colorado	862	908	82	37	30	22	13*		1092
Idaho	222	546	36	23	19	7	4		635
Montana	130	424	39	21	13	4			501
Nevada	45								
New Mexico	165	23	10	9	12	9	5*		68
Oregon	85	319	14	15	3	5*			356
Utah	68								
Washington	141	262	6	11	6	7			292
Wyoming	35								
Sub-Total	3278	2643	261	200	148	112	50	16	3430
TOTAL - 39 PRIMARY FEEDING STATES	12762	182308	1008	551	331	207	108	37	184550

1/ Based on USDA Statistical Reporting Service Publication Mt An 2-1 (1-71) Cattle on Feed.
2/ Breakdown of feedlots by head capacity available only in 22 major feeding states and North Dakota.
* Includes one or more larger capacity lots.

Table 3
Daily Production and Composition of Animal Manure
(1) (2) (3) (4) (5) (6)

Animal	Manure	5-day BOD	COD	Total Solids	Volatile Solids	N	P	K
	(Production in lbs/day)							
1200-1400 lbs. Dairy Cattle	100	2.0	9.0	10	8	0.38	0.10	0.31
800-1000 lbs. Beef Cattle	75	1.5	7.0	10	7	0.52	0.15	0.34
100 lbs. Sheep	4.0	0.25	0.75	1.05	0.86	0.04	0.012	0.04
150 lbs. Hogs	8.5	0.32	0.70	1.0	0.6	0.07	0.04	0.06
4 lbs. Poultry	0.25	0.015	0.05	0.065	0.042	0.003	0.003	0.002
4 lbs. Broilers	0.25	0.015	0.05	0.065	0.042	0.003	0.003	0.002
1000 lbs. Horses	56	1.4			8	0.48	0.07	
People	3.9	0.17	0.44	0.55		0.033	0.03	

1. Davis, E. H., 1969. Animal Waste Data and Population Equivalents. E.M. 2592 Cooperative Extension Service. Washington State University

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5. Anderson, M. S., 1957. Farm Manure. The 1957 Yearbook of Agriculture.

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WATER MANAGEMENT

Paul Koluvek

It has been stated that irrigation return flow affects the quality of our water supply. Irrigation return flow is defined as any water diverted for irrigation purposes that finds its way back into a source of supply (stream or groundwater basin). This includes bypass water, deep percolation losses, tail water runoff and seepage. Figure 1 gives a model of the irrigation return flow system and the effect of the water-plant-soil complex on the quantity and quality of irrigation return flows. Table 1 presents the probable changes that take place in quality as a result of irrigation for various pollutants. It stands to reason that if irrigation return flow is reduced, the quantity of pollutants would be reduced. (Figure 1 and Table 1 taken from Water Quality Management Problems in Arid Regions, Federal Water Quality Administration, U.S. Department of the Interior, Oct. 1970, and Characteristics and Pollution Problems of Irrigation Return Flow, Federal Water Pollution Control Administration, U.S. Department of the Interior, May 1969.)

In reviewing Figure 1, there are a number of sources that go into irrigation return flow where Service practices can be applied to reduce the return flow. The sources where these practices can be applied are: tail water runoff, deep percolation, and field ditch and canal seepage. Another item that can be reduced, which has an indirect effect on quality of irrigation return flow, is evaporation of water from irrigated lands. The major contributors to irrigation return flow are tail water runoff and deep percolation. How can the water user or irrigation farmer reduce his irrigation return flow? By applying the one irrigation practice that would have the greatest impact -- conservation irrigation water management.

Irrigation Water Management

What is irrigation water management? Management is the act of controlling or regulating. Therefore, conservation irrigation water management is simply the act of controlling or regulating irrigation water applications in a way that will insure high crop production without the waste of either water or soil. It involves applying water in accordance with crop needs, in amounts that can be retained in the soil for crop use, and at rates that are consistent with intake characteristics of the soil and erosion hazard of the site.

Irrigation water management is something the irrigator does to control or regulate the application of water -- not the facilities he employs. For example, an irrigator may install a headgate to control the flow of water onto a field. The headgate itself provides no water management. The water is managed when the irrigator opens the gate to deliver water to the field

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or closes the gate to stop delivery. It involves mental as well as physical acts. The irrigator must make certain decisions before he performs the physical acts of irrigation. He must decide when to open the gate, how far it should be opened and when it should be closed. In fact, the ability to make sound water management decisions is the most important aspect of conservation water management.

In order to make sound decisions, the irrigator must have an understanding of the basic principles involved. He must have a general idea of how water is held in the soil for plant use and how much water his soils hold. He needs to know how to judge when an irrigation is needed, and how much is needed. He needs to have a general understanding of soil intake characteristics and of the required adjustments in stream sizes and time of water application needed to fit the intake characteristics of his soils.

In Table 2, a comparison is made of an irrigation where irrigation water management is practiced, and of one where it is not practiced. In the comparison, only those factors of the irrigation that affect return flow and pollution are considered. It is recognized that the statements in Table 2 reflect extreme conditions and are over-simplifications. This was necessary in order to emphasize the need for conservation irrigation water management as a tool for reducing pollution of irrigation return flow.

There are many tools available for irrigation water management. The USDA and the Service have prepared bulletins and handbooks on irrigation water management. The SCS Training Center has held a large number of sessions where Service employees have received training in applying techniques of irrigation water management, but how many of these employees are applying what they have learned?

The primary SCS objectives in the field of irrigation water management are to give farmers and water users an understanding of conservation irrigation principles; to show them how they can judge the effectiveness of their own irrigation practices, and to help them make needed adjustments in old systems or install new systems. This brings up the second part of water management -- irrigation systems.

Irrigation Systems

A poor irrigation system, with the best irrigation water management techniques applied, will cause waste of water because poor application and distribution will occur. A poor system is one that does not have the capacity to meet the peak-use requirements of the crop, and cannot deliver the required rate for the irrigation method used. Thus, a conservation farm irrigation system is a factor in water management.

A conservation farm irrigation system consists of three parts -- delivery, application, and disposal. These facilities are arranged so as to deliver and apply irrigation water efficiently to, and dispose of waste water from, all land served by the system. The system must be carefully planned to fit the soils and topographic conditions of the site for effective and

efficient use of water. An irrigation plan should set forth the specifications and requirements for efficient system operation. The system must be operated in accordance with the prepared plan and the crop needs, if optimum yields are to be obtained with minimum waste of water.

Many irrigation systems use earthen canals and field and tail water ditches to convey water. In examining Figure 1, it will be noted that seepage from these ditches contribute toward irrigation return flow. The water that seeps from the ditches can pick up salts as it percolates through the soil, which adds to the pollution of irrigation return flow. These seepage losses can be greatly reduced by lining the ditches or by using pipelines. The same thing would apply to irrigation reservoirs, which are part of an irrigation system in some areas. In addition, several side benefits are obtained from lining ditches. Generally, the water surface area is reduced, thus evaporation is reduced, and weeds and phreatophytes are eliminated, thereby eliminating transpiration. This results in reducing the concentration of pollutants in the irrigation water.

With some methods of water application, surface runoff will occur. Surface runoff is a component of tail water as shown in Figure 1. When surface runoff or storm runoff is anticipated, some provisions for disposal are needed.

One way of reducing surface runoff is by using a method of application where little or no surface runoff would occur due to irrigation. This is discussed further under "Methods of Application." Another means of reducing runoff is by recovering surface runoff and reusing it on the farm enterprise. This can be an effective method of reducing tail water.

Groundwater is another component of tail water, and is the water which is removed by deep, open ditches or tile. Generally the quality of groundwater is poor. In the arid areas it will have a high concentration of salts, as indicated in Table 1. In some of the irrigated areas, high concentrations of nitrate have been found in tile effluent. Other than irrigation water management, there is little that the individual farmer can do to reduce groundwater.

Collectively, a group of farmers could reduce the effect of groundwater on irrigation return flow. The groundwater could be separated from the tail water and diverted to a point where it would not be objectionable.

Another way to handle groundwater would be by storing the water in a reservoir and letting it evaporate, or it could be stored and then released during high flows into a river. This would dilute the pollutants to a level where they would not be objectionable.

Some of the groundwater can be reused if the quality is not detrimental. This is being done in some areas. It can be collected in a sump and

returned to the irrigation system. It might be collected in the surface runoff collector system and reused with the surface runoff. A good example or maybe a bad example of groundwater reuse is in nearby Mexico. Groundwater from the Welton-Mohawk area in Arizona, is being reused in the Mexicali Valley of Baja, California. The water is reused during the peak demands from the Colorado River. This groundwater is being mixed with relatively good water thus reducing its toxic potency although at times the resulting mixture may go as high as about 2400 ppm.

Another aspect of groundwater removal is the nitrate problem. If groundwater has a high nitrate content, it could increase algae growth in open drains and thus clog the system. Recent research indicates that nitrate concentrations can be reduced in tile effluent by submerging the tile lines. This creates a condition conductive to denitrification; thus design concepts for tile drains may have to be changed.

Supplement to Water Management

One aspect of water management that has received little attention, is flexibility of irrigation water delivery. Many irrigation districts and farm enterprises are inflexible in their delivery of water. A more flexible arrangement of delivering water would permit higher application efficiencies which would result in less waste of water and a number of other benefits. The definition of flexibility as used here is the delivery of water so that it can be varied in frequency, rate of flow, and duration. The following discussion examines the three factors of flexibility and how they affect water management.

Frequency is expressed in the terms of the irrigation schedule -- when, what rate, how long is the water available. The fundamental concern in establishing a schedule should be to give the irrigator the depth of water he needs to replace soil moisture deficiency at the time it is needed. In practice, one will find anything from rigid to flexible schedules.

An extreme example of a rigid schedule is where the irrigator gets the same amount of water each irrigation at a certain fixed interval. This type of schedule would not allow much irrigation water management, and would waste the greatest quantity of water.

An example of a flexible schedule is where the water is available at the time needed regardless of the quantity needed. This type of schedule would allow maximum irrigation water management, thus wasting the least water.

The need for flexibility of rate of flow will vary with the method of application. For border irrigation, there is no need to vary the rate at any one irrigation, but there is the need to vary the rate during the irrigation season for a number of reasons. In furrow irrigation, there is a need to vary the flow during any one irrigation as well as during the irrigation season. The reason for changing the rate during an irriga-

tion is that the stream size should be cut back when the water reaches the ends of the furrows. In most irrigation districts this cannot be done because the irrigation systems are not designed to take care of extreme fluctuations. Generally, a considerable amount of water is wasted with furrow irrigation. For sprinkler irrigation, there is little need for changing rates of flow if the sprinkler system is properly designed.

Flexibility in duration of flow is also important. Durations deal with the length of time water will flow. In most districts water is delivered for a given time period. If the irrigator finishes earlier than he planned, because intake characteristics have changed, he must continue taking the water until the time period is up. This causes some waste of water. Duration is directly related to rate of flow, and the two of them must be balanced in order to arrive at the volume of water needed.

One way that flexibility can be introduced into a farm irrigation system is by the use of irrigation reservoirs to take up the slack. This is being done by some areas.

Methods of Application

A part of conservation farm irrigation planning is the method of application. The ideal irrigation method would be one that would have the capability of applying water precisely with a field application and distribution efficiency of nearly 100 percent. Such a method would not contribute anything toward irrigation return flow. As a result there would not be an immediate pollution problem.

At present there is no method of application where this can be achieved, and even if it could be achieved, consideration would have to be given to an eventual salt build-up.

All methods of water application contribute some water toward irrigation return flow. The following gives an indication of what application efficiency might be achieved for various methods of application if designed properly and irrigation water management is practiced:

Method	Application Efficiency
Level border (basin)	75 to 85%
Graded border	70 to 80%
Graded or level furrow (corrugation)	75 to 90%
Sprinkler	75 to 80%

Many factors must be considered in selecting any one of the methods available. National Engineering Handbook; Section 15, Irrigation; Chapter 3, Planning Farm Irrigation Systems, covers the various methods of applying irrigation water. Other chapters are available or will be available which cover the planning aspects of these methods. This paper will cover, princi-

pally, only some new approaches in methods of application, or improvements for existing methods. Eliminating surface runoff was mentioned earlier as one way to reduce tail water. The use of level border or level furrow is one of the best ways of doing this.

Arizona has taken the lead in using this mode of water application, with the outstanding area being Yuma. In California, this procedure is being used in Coachella, Palo Verde, and Bard valleys. These areas have no means for disposing of surface runoff, thus all the water must infiltrate into the soil. The key to this method is large heads (15 CFS or more) of water with minimum advance time. In Coachella Valley, small heads (3 CFS) are used, but the border widths are narrow and rather short, and are used in vineyards and citrus orchards which are well suited to this method.

The row crop farmer uses several means to reduce surface runoff. One is the use of sprinklers for germination where light, frequent applications are needed. Once the crop has reached some size, conventional furrow irrigation is used. Sprinkler irrigation has several other advantages. It provides cooling for earlier germination, and leaches salts out of the furrow bed, providing a better environment for seed germination and plant growth. It also reduces deep percolation losses.

A portable system of gated pipe is used by some growers to shorten irrigation runs for light applications. Usually the irrigation runs are about 1,300 or 2,600 feet. These are cut to about 660 feet with the gated pipe system. The system involves the use of a portable pump, aluminum supply pipe, and aluminum gated pipe. The pump is used to develop a head of water since the fields are normally irrigated by a gravity system.

Some growers are reducing surface runoff by the use of furrow tappoons which are similar to portable checks used in head ditches. Tappoons are placed in a series in about the lower quarter of the field and are spaced from 20 to 100 feet, depending on the slope. Their purpose is to form small basins in the furrow which increase the wetted perimeter, thus speeding up wetting of the furrow bed. Actually, the intake rate is increased which affects surface runoff. Furrow tappoons are made of sheet metal, plastic, or treated paper, and have a small notch on the top which allows the water to flow over and not around the tappoon.

Surface runoff can be reduced by flattening the lower quarter or third of a field. This reduces the velocity of the water flowing across the lower end and allows more time for water to infiltrate into the soil. It provides for a more uniform application, and can reduce deep percolation loss at the upper end of a field.

Farmers in some areas are converting from surface to sprinkler irrigation, which is eliminating surface runoff although they may be increasing deep percolation because of poor management. This is especially true in orchards -- solid set or pull hose. Both are designed to apply not more

than 1 gpm per sprinkler head, with a sprinkler head located at each tree. Both systems save water and reduce labor. The solid set lends itself very well to total automation.

A new method of applying water is being tried in at least 15 states although Southern California probably has the largest number of installations. This new method is called "drip-irrigation." It is being advertised as a new concept in water and nutrient distribution. Whether or not it is revolutionary is a matter of opinion. Basically, drip-irrigation is the application of water through a very small orifice at a rate of about one gallon per hour at about 15 psi, and could be thought of as a tiny furrow. It applies water at a rate that is less than the infiltration rate of the soil, and involves nonsaturated flow in the soil.

There are claims of water savings up to 90 percent with this method although recent research by Dr. Leon Bernstein, U.S. Salinity Laboratory, USDA, Riverside, California, indicates a total water savings of about 25 percent as compared to sprinkler irrigation.

Most of this water was saved during the premature stage, which would be expected. As one SCS engineer stated in San Diego County, California, "If it is found that large volumes of water are saved using drip irrigation, then large volumes are being wasted by the old method."

With the use of drip irrigation, there is a change toward more precise measurement and management. Tensiometers are more widely used with this system to tell when to irrigate. More pressure regulators are used to properly distribute water and fertilizer. Some systems are fully automatic, using electrical tensiometers to turn the system on and off. This precision reduces the human error factor and increases irrigation efficiency. While a number of questions need answering, this method of application is here to stay. It is being used in orchards and with vegetable crops. It is one of two systems that approach precise irrigation, eliminating surface runoff and reducing deep percolation losses.

The other system is a new concept in subirrigation which involves the underground installation of small plastic pipe with small orifices. Water is applied at a very low rate, at low pressures. Presently it is not being used extensively, but should gain in use. Results have been very good. It has been used with citrus, row crops, pastures, golf courses, and around homes. Water saving is about the same as for drip irrigation.

In closing, it can be said that no matter how well an irrigation system is designed, if it is not operated and managed properly, water will be wasted, and pollution of irrigation return flow will continue. Therefore, conservation irrigation water management is one of the major keys to pollution abatement as part of the farm program.

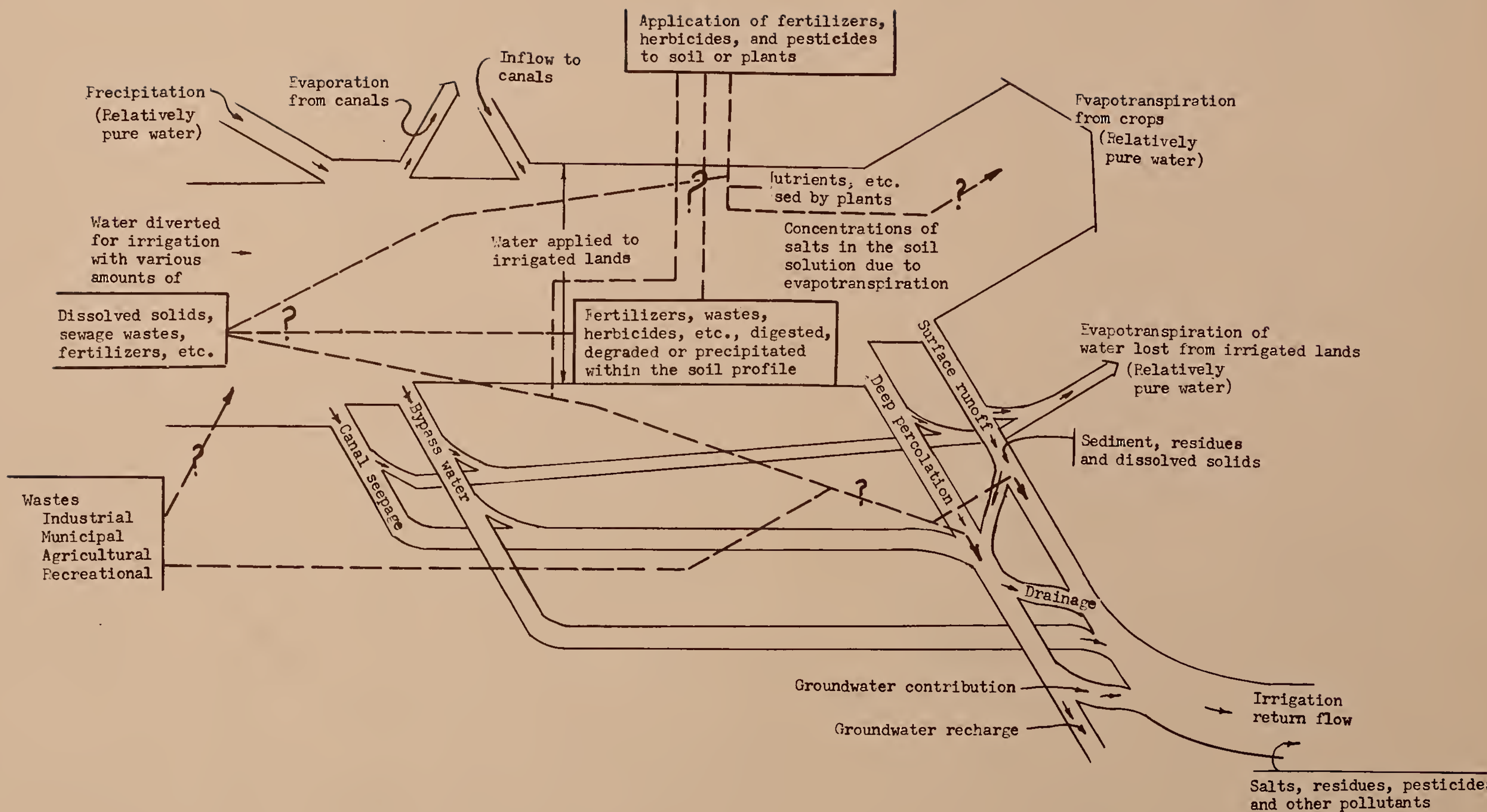
TABLE 1

PROBABLE CHANGES IN QUALITY AS A RESULT OF IRRIGATION

Quality Factors	Irrigation Return Flow: Surface	Irrigation Return Flow: Subsurface Drainage
Salts (TDS)	Not greatly different from sources	Concentration increased usually 2-7 times. Depends on amount in the supply, number of times reused, the amount of residual salts being removed, and the amount from non-agricultural sources.
Sodium and Chloride Ions	Relatively unchanged.	Both proportions and concentration likely to increase.
Nitrate	More likely a slight increase than a decrease and highly variable.	Likely to decrease if the content in irrigation water is high and increase if amounts are low. Greatest hazard from heavily fertilized porous soils over irrigated.
Phosphate	Content may increase, but closely correlated with erosion of fertile topsoil.	Decrease if considerable in source. Not likely to greatly increase.
Pesticides	Highly variable content. Surface waters subject to polluting. Likely associated with amount of erosion.	A reduction in many instances. Concentrations likely to be low.
Pathogens and other Organisms	Variable and may increase or decrease.	Low content with a likely reduction in most all pathogens. Other organisms may increase or decrease.
Sediments and Colloids	Often more than in source but may be less--highly variable.	Little or no sediment or colloidal materials in the flow.
Organics	Manures, debris, etc., likely to increase	Most oxidizable and degradable materials to decrease.
Heavy Metals	Kinds and amounts are variable. Likely to be greater than in subsurface flow.	More likely to decrease in concentration.
Sewage Effluent	Not greatly changed except by filtering and oxidation effect of crops if sprinkled.	Concentration of all pollutants reduced except common soluble salts.

TABLE 2

Conservation Irrigation Water Management	Without Conservation Irrigation Water Management
1. Surface Runoff - Will be nonexistent or at best at a minimum, depending on the method of application. This will result in minimum pollution of irrigation return flow.	Will be at a maximum depending on the method of application. This will result in maximum pollution of irrigation return flow.
2. Deep Percolation Loss - Will be at a minimum depending on method of application. Groundwater will have a high concentration of pollutants (primarily salts).	Will be at a maximum depending on method of application. Groundwater will have a maximum amount of pollutants but will not be as concentrated as with water management.
3. Timing of Irrigation - Will result in minimum amount of water applied. This will reduce the amount of salts applied, which in turn reduces the leaching requirement thus reducing deep percolation. Surface evaporation will also be reduced because of less frequent irrigations.	Will result in maximum amounts of water applied. This will increase the amount of salts applied, which in turn increases the leaching requirement thus increasing deep percolation. Surface evaporation will also be increased because of more frequent irrigation.



Precipitation (Relatively pure water)
Evaporation from canals
Inflow to canals
Application of fertilizers, herbicides, and pesticides to soil or plants
Evapotranspiration from crops (Relatively pure water)
Nutrients, etc. used by plants
Concentrations of salts in the soil solution due to evapotranspiration
Water diverted for irrigation with various amounts of
Dissolved solids, sewage wastes, fertilizers, etc.
Water applied to irrigated lands
Fertilizers, wastes, herbicides, etc., digested, degraded or precipitated within the soil profile
Evapotranspiration of water lost from irrigated lands (Relatively pure water)
Surface runoff
Deep percolation
Bypass water
Canal seepage
Sediment, residues and dissolved solids
Wastes
Industrial
Municipal
Agricultural
Recreational
Drainage
Groundwater contribution
Groundwater recharge
Irrigation return flow
Salts, residues, pesticides and other pollutants

FIGURE 1

WATER TEMPERATURE MANAGEMENT FOR FISH AND AQUATIC HABITAT

L. Dean Marriage

INTRODUCTION

Fish and other organisms requiring aquatic habitat are dependent on a combination of environmental factors for successful perpetuation of their kind.

Temperature is but one of the environmental factors that determines which aquatic organisms will thrive and which will diminish in numbers or cease to exist. This paper will discuss the potential of Soil Conservation Service's programs and activities to manage water temperature.

A rise in water temperature (1) decreases water's ability to absorb dissolved oxygen, (2) increases metabolism, respiration and oxygen demand of fish and other aquatic life, (3) intensifies the toxicity of many substances and (4) favors the growth of fungus and undesirable bacteria.

At the outset of this presentation, it is important to realize that within limits water temperature <u>is</u> manageable and many of SCS's programs and activities do affect water temperature.

By knowing something of water's physical and chemical characteristics, understanding the factors influencing temperature changes, and having a knowledge of the optimum, minimum and maximum temperature tolerances for the animal or plant species to be favored or controlled, a plan can be formulated that will accomplish the temperature management desired.

An uncontrolled and unplanned temperature change is mismanagement and misuse of a resource that often results in thermal pollution.

All states have developed and adopted water quality standards in recent years as a result of the Federal Water Pollution Control Act as amended by the Water Quality Act of 1965. These water quality standards are state law and enforceable. Non-compliance is punishable by fines or imprisonment or both. Engineers, resource planners, plant scientists and other SCS specialists should be aware of the water quality standards for their respective state in detail.

Water temperature standards for the State of Idaho will serve as an example of the allowable temperature deviations: "No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in these waters .....any measurable (temperature) increase when stream temperatures are 68° F. or above, or more than 2° F. increase when stream temperatures are 66° F. or less" (from Section 1.D Temperature for Public Waters of the Bear River, Bear Lake, Cub River, Worm Creek and the Malad River----words in parenthesis added for clarity).

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Permits are now being required by the U. S. Army Corps of Engineers for discharge of wastes into a navigable stream, or into any body of water which eventually reaches a navigable stream, except through a municipal sewage system. The discharge of wastes from fish farms, pay lakes, fish tanks, and farm ponds where fish are cultured or held come within the meaning of this new federal regulation. Interestingly, the authority is contained in the Refuse Act of 1899, only recently re-activated and re-oriented by a presidential executive order.1/ The permit is dovetailed to the state and interstate water quality standards which includes the water temperature standards.

Many Service recommendations, designs, and engineering standards and specifications, if followed through to installation, will have an effect on water temperature. Do you know the magnitude and nature of the change? Or what effect the change will have on the project purposes? Are you willing to stake your reputation on the design or activity you are proposing that it will or will not meet water temperature and other water quality standards? Would additional training be beneficial to your understanding of the subject?

SCS PROGRAMS AND ACTIVITIES AFFECTING WATER TEMPERATURES

In this section are listed some of the major causes and opportunities for temperature change or management attributable to Service programs and activities.

Land Treatment

Nearly any conservation practice altering the quantity or quality of vegetative cover can alter water temperatures of streams within the watershed. One such activity that has been receiving a lot of attention in recent years is logging. A recent study in North Coastal area of California2/ showed that "after logging and associated road construction during 1968 and 1969, the greatest effect was noted on stream temperatures. Maximum temperatures increased 6° F. following alternate block cutting adjacent to one experimental stream and 17° F. in one stream after road right-of-way clearing adjacent to the stream and road material excavation (244,000 cubic yards) along a 3.7 mile section of stream. No temperature change was noted on one stream subjected to selective logging with retention of an uncut buffer strip (1,000 feet along both sides of the stream). Temperature increased 5.5° F/1,000 ft. as the stream flowed through clear cut sections and decreased 2.5° F./1,000 ft. while flowing through uncut sections."

A study of Bluewater Creek, Montana3/ showed that agricultural activities caused an increase in turbidity and a corresponding increase in water temperature. It follows that silt-reducing land treatment practices such

1/ See also Federal Register December 31, 1970.
2/ "Water Quality of Some Logged and Unlogged California Streams" by Frederic R. Kopperdahl, James W. Burns, & Gary E. Smith.
3/ "Effects on a Trout Stream of Sediment from Agricultural Practices" by John C. Peters. The Journal of Wildlife Management, Vol. 31, No. 4, Oct. 1967, pp. 805-812.

as streambank protection, grassed waterways, livestock exclusion, and proper grazing use and the like will also have a direct effect on water temperature. The magnitude of this effect would be generally in proportion to the turbidity of the stream.

Pond and Reservoir Construction

These activities offer significant opportunities for water temperature management. Standing waters have maximum opportunity for exposure to factors causing temperature change and with few exceptions, exhibit varying degrees of temperature density - and pressure dependent stratification at one or more seasons of the year. Even farm ponds as shallow as 10 feet are known to stratify. The possibility exists of designing primary spillways or outlets which are capable of spilling or releasing water from strata of known or predictable temperature.

To oversimplify, a surface spill on a temperature stratified reservoir during the summer will tend to remove the warmer, less dense (lighter) waters leaving the cooler, more dense (heavier) waters. Conversely, a spilling or withdrawal of the cooler, more dense waters from the bottom will tend to warm a reservoir. By installing a spillway with outlets at different elevations, a degree of flexibility is assured for producing desired water temperature both within and downstream from the reservoir. The ability to control reservoir temperatures depends on reservoir size and shape, degree of stratification, dissolved gases, inflow quantity and quality and other factors. The Corps of Engineers, Environmental Protection Agency, Tennessee Valley Authority, Bureau of Reclamation and others are now employing the use of computer models for predicting reservoir and outlet temperatures for proposed reservoirs. Major factors affecting the temperature regimen are identified, estimated or measured. and placed in a heat budget formula.[4/] Using this system it is possible to select the desired downstream (outlet) temperature(s) and analyze the probability of being able to accomplish this with the proposed design and assumed operation schedule. A similar procedure is used for predicting the temperature change in released water as it is transported downstream.

This planning tool offers hope to meet desired management objectives and to avoid conflicts with fisheries values, particularly when dealing with trout and salmon streams. It is not only being employed for temperature prediction but also for predicting concentration of dissolved gases and other pollution parameters.

Farm Ponds - Several SCS designs of bottom-water overflows have been used in the Western states. A bottom-water overflow is an outlet that automatically releases pond overflows from bottom-waters. The management objective in most cases is to prevent winter kill of fishes by the automatic withdrawal of toxic or oxygenless bottom waters brought about by the decay of organic matter under an ice and snow cover. It is also

4/ For example, "A Predictive Model for Thermal Stratification and Water Quality in Reservoirs" by Mark Markofsky and D.R.F. Harleman. Report No. 134, Jan. 1971, Dept. of Civil Engineering, Mass. Inst. of Technology.

useful in attaining warmer spring temperatures for extending the growing season for cold water fishes. By providing the flexibility of a controllable surface port in the spillway design, either surface or bottom waters can be spilled to accomplish warming or cooling of reservoir waters. Experience is accumulating - that proves the worth of this management device in the Western states.

Temporary relief from critically high pond water temperatures and dissolved oxygen levels is attained in some instances by pumping cooler waters from wells or other sources into ponds and raceways. Two or three degrees reduction in water temperature can determine survival when water temperatures are at the upper tolerance limit for the fish species affected. Circulation and cooling in ponds may also be achieved by jetting pumped well water or pond water into the pond parallel to the edge, or using air guns to bring cooler bottom waters to the surface. In the latter instance care must be taken to begin using the air guns before oxygenless bottom waters reach sufficient volume to critically reduce the supply of oxygen in the remaining waters. Similarly, toxic gas-laden bottom waters can also be a problem.

Irrigation Reservoirs - This kind of reservoir is characterized by fluctuation in reservoir elevation brought about by storage and subsequent release of waters for this purpose. Because of the high ratio of irrigation storage to total storage, water temperatures both within and downstream of the reservoir can be significantly affected. Careful consideration should be given in the design phase to planning the principle spillway to meet the desired water requirements for the aquatic species to be affected----i.e., outlet elevations and multi-level orifices. Reservoir operation schedules should be developed with all uses of released and stored water in mind.

Flood Prevention Reservoirs - Dry structures - The use of 'dry' structures may be employed where no effect on downstream water temperatures is desired. A dry structure is one that has only temporary storage----a few hours to a few days. The tube through the dam is sized to release water quantities that can be safely accommodated by the downstream channel capacity. Where fish passage is desired the gradient of the tube can be usually adjusted to attain the desired water depth and velocities.

Wet Structures - This kind of structure contains permanent or seasonal storage. Flood storage is accomplished in the storage capacity above the sediment or conservation pool and therefore usually results in a fluctuating water surface of short duration----hours to days. Because of the conservation pool, all of the factors that cause temperature change in lentic waters come to bear. Again, careful consideration should be given in the design phase to planning the principle spillway to meet the water temperature requirements for aquatic organisms affected.

Recreation and Multipurpose Reservoirs - A common challenge is to get many uses out of water storage----to reach an acceptable compromise of the many uses to which the stored water will be put. A multipurpose reservoir may have such beneficial planned uses as irrigation, flood prevention, M&I,

pollution control, boating, fishing, and other forms of recreation. It is extremely important that quality (including temperature) is not sacrificed in planning for these uses. Where waters are to be released downstream, the design of the principle spillway and the development of the reservoir operation schedule becomes all important. Perhaps dual use can be made of released irrigation waters for maintaining a stream fishery between the dam and the irrigation diversion structure. Perhaps the elevation of the irrigation outlet(s) can be altered to accomplish withdrawal of waters of a desired temperature or quality from the reservoir.

Channel or Stream Improvement

Much attention has been given the subject of so-called channelization in recent months by conservationists, professional biologists, Congressmen, professional societies and private citizens. A congressional committee hearing was recently held on the matter. Most view it as an environmental degrading type activity causing reduced fisheries carrying capacity; destruction of pool-riffle stream characteristics; destruction of streamside vegetation; elimination of waterfowl habitat; and general esthetic degradation. Suffice to say this is a sensitive area worthy of our detailed study. I will only mention those temperature related considerations and what can be done.

Shade - Shade is very important to maintaining cool water temperatures in the streams and channels. Several research workers' results have already been quoted. Too much shade reduces food production for fish. In water courses less than 15 feet wide, rely on grasses and annuals to provide streamside cover. On streams 15-30 feet wide low shrubs are suggested. On streams over 30 feet shrubs and trees can be planted but the effect of streamside shade on larger streams is not as great as on small streams. When channel improvements are indicated remove as little streamside vegetation as possible and revegetate disturbed banks with suitable plant materials.

Cover - Whether caused by streamside vegetation, by undercut banks, sunken logs or boulders, cover not only provides shade but also hiding cover for trout. In Michigan and Wisconsin cantilevered banks constructed by stream improvement crews have increased the carrying capacity by about 50 percent and angling success by over 500 percent. In combination with stream deflectors, maximum water temperatures were lowered 5° F.

Most fishery biologists define another type of cover----water depth of 2 or more feet. Other things being equal, a stream with a shallow water depth will have a higher temperature than one with deeper water.

When channelization is indicated avoid disturbance of cover wherever possible. The addition of log sills on silt or sandy bottom streams will create a pool downstream of the plunge.

The use of flow deflector structures and tilted channel bottoms or low flow notches in bottoms of constructed channels will concentrate low flows and tend to reduce water temperatures as well as provide more swimming depth for fish and uncover gravel bars.

Pool-riffle Association - Under natural conditions pools or riffles are repeated every five to seven channel widths. Generally, the pool is the resting area for fish and the riffle the feeding area. In a constructed channel a meander flow pattern and pool riffle association can be accomplished by the installation of deflectors and bank protection if deeper channels for hiding and resting areas are needed or if velocities are insufficient to keep gravel bottoms clean of sediment.

Channelization damages to wildlife can be minimized or avoided if care is taken in the design phase. A detailed on-site examination by a team consisting of a biologist, an engineer, and a geologist will go a long ways in avoiding conflicts. The stream section should be examined foot by foot and critical areas identified for flood control needs, fishery needs, and other values. The highly criticized 'conventional' straight and uniform cross section channel will most often be avoided if this approach is taken. Development of standards for retaining or developing aquatic habitat are being prepared.

Fish Facilities

The Service gives assistance to private land owners and operators in the selection of the site and construction of fish rearing facilities and hatcheries. Temperature is very important in planning these facilities since all fish have rather narrow temperature tolerances for physiological processes. Optimum growing temperatures are most often different than optimum spawning temperatures. The water supply, method of delivery and ability to maintain given water temperatures means the success or failure of an enterprise. In instances such as Royal Catfish of Jerome, Idaho, the manager has two water supplies----one, the conventional 58° spring water for that area (ideal for growing trout); and the other a 1200 gpm artesian well of 110° F. By proportionate mixing of these two sources ideal growing temperatures are obtained for channel catfish. The manager is presently experimenting with various delivery and mixing systems to attain the desired result. The Service has been assisting in this enterprise.

In near-marginal areas for trout the number of 100 ft. raceway sections one can place in series becomes critical. As cool spring waters are progressively exposed to warmer air and ground temperatures in each subsequent raceway, they warm above the safe temperatures for growing trout. Judgment and experience is needed to advise fishery enterprises with this problem. In Tennessee a trout grower is growing channel catfish in the lowermost raceway and trout in the upper raceways.

Shed covers over raceways are used in some instances to provide shade in the summer and snow and ice protection in the winter.

Heat exchange units for cooling and heating are being installed in larger trout and salmon rearing facilities having closed circulation systems.

Irrigation

Efficient irrigation management goes hand in hand with good water temperature management. One of the main concerns in fisheries management where irrigation is practiced is in the potential for poor quality of return

flow resulting from over application of water. These waters are often high in nutrients and dissolved salts and nearly always warmer than when diverted from their source. The trend of converting from the less efficient flood irrigation to sprinkler irrigation is helping in this thermal pollution problem. Even heated waters, if applied through a sprinkler, will reach air temperatures or below in 12 feet of fall regardless of beginning temperature. However, there is no substitute for efficient water management regardless of the method of application.

Where return flow is unavoidable, collection and re-use systems can be installed to prevent their entry into free flowing streams.

Estuary Alteration

Estuaries - where the rivers mix with the sea - are a delicately balanced, highly productive biological system. Oysters and clams, for example, are highly dependent on water temperatures to successfully spawn and metamorphose to adult-like animals. Water temperatures are in turn dependent on the proportion of sea and fresh water entering and leaving the estuary, climatic factors, the range of tides, and the size and shape of the estuary. As the size and shape is altered by excessive silt deposition from the watershed and by diking and filling activities for building and industrial sites, the flushing pattern is changed and temperatures and current patterns are affected. If sufficient changes occur, the oysters and clams fail to reproduce and permanent damage to the resource results.

So that all uses and values of estuaries are given fair consideration, it is mandatory that each estuary have a land and water use plan recognizing basic human needs while retaining natural environmental values. The Service has participated in several of these plans.

FUTURE ACTION AND DATA NEEDS

As can be seen, Service programs and activities can exert a considerable influence on water temperatures. It is important we understand in the clearest way possible the consequences of our recommendations.

We must give proper recognition to state and interstate water quality standards in the planning and construction of project measures in Service projects whether a PL-566 project, an RC&D project, or a farm pond.

A better procedure is needed for predicting a projects probable effect on water temperature and other water qualities. Several prediction systems are now employed by other governmental agencies.

We need to supplement the existing number and kinds of environmental quality monitoring stations so we can be more responsive to environmental needs. These data will assist us greatly in assessing the consequences of our various programs and activities. Several before and after watershed project construction studies need to be initiated to assist us in making better decisions in the future.

The projects should be selected on the basis of being representative of conditions commonly confronted or experienced in the West.

Key specialists should be given training in recognizing and understanding pollution caused by man. Excellent short courses are available from local colleges and universities and from the teaching staff of the Environmental Protection Agency.

Immediate attention needs to be given to the team approach to minimizing damages to the environment through channelization activities. The foot-by-foot examination of channelization proposals leading to on-site decisions of a multi-discipline team will go a long way in minimizing conflicts with environmentalists through avoidance of unnecessary physical alterations.

There should be a continuing review and revision of policies, programs, standards and specifications, conservation practices, and designs having an impact on environmental quality. When it is considered an equal project purpose to other commonly recognized project purposes, the Service will have placed environmental quality in the proper perspective.

CHANNEL IMPROVEMENTS

Roy L. Fox

On behalf of Service personnel in Oregon, I appreciate the opportunity of participating in this workshop. The prior discussions will be of help to us, and I hope that our thoughts will be of use to you.

I am sure that all of you have heard, seen, or read some of the recent critical material on channel improvements published under such headings as Channelization, Canalization, Stream Enlargements, Drainage, and Floodways.

As a start toward a more positive approach, we should think of most of this work under an all inclusive heading of Stream Corridor Improvement. For that is what it is, or what it should be.

What is Stream Corridor Improvement? It is all of the man influenced actions, either natural or structural, that have a beneficial effect on the environmental aspects of the closely related interdependent resources within the strip traversed by the stream.

One can readily recognize that this concept is fraught with details that defy description. Yet these same details may greatly affect or be affected by a seemingly simple definable action; such as, manipulation of a channel's gradient, cross section, plant cover or even associated wildlife. For example, take the matter of erosion, both normal and accelerated, and try to relate these to the constantly changing conditions imposed on a stream by man and nature. Overall, man ends up trying to achieve the best coexistence he can for what is all too brief a time when compared to the life of the stream.

Now the subject of Stream Corridor Improvement is large and complex, and it would take many people and much time to cover it adequately. However, no single aspect of it can be considered without occasional reference to the total subject, broad objectives, or interdisciplinary approaches. I trust that you will permit me this liberty today.

My assigned topic, which I will, in my own way, try to stick to as closely as possible, is "Channel Improvements" with emphasis on two things:

1. Methods of minimizing disturbance to streams during channel construction in order to prevent increases in turbidity during this period.

2. Methods of treating newly constructed channels to control erosion of the banks and rights-of-way.

Roy L. Fox, State Conservation Engineer, Soil Conservation Service, Portland, Oregon

I don't believe we need to spend any time convincing each other, with words and facts, of the need to do this. Recent adverse publicity and our own prior discussions this week have deeply embedded into our minds the need for betterment.

To focus our attention to a closer discussion of the channel improvement aspect of Stream Corridor Improvement I will, in order to maintain a reasonable division and sequence, talk about these four items: (1) mental attitudes, (2) design, (3) installation, and (4) operation and maintenance.

Of these four, the first one Mental Attitudes is by far the most important for it is the foundation upon which all else rests.

Success or failure, or something in between, depends upon how each one who has a part reacts to objectives, criteria, methods, guidelines, and even to Service or public policy.

Within the field of construction, earth moving, or earth disturbance as some people view it, is one item where technological development has resulted in a steady trend to increased productivity at unit costs that remain always favorable. The result, on all types of construction, has been the movement of more earth and more and longer earth disturbance.

The exercise of self-restraint in earth moving and/or the selection of other alternatives that will create less disturbance, and less erosion and pollution, is a foremost necessity.

Likewise, at all steps of design, installation, and operation there are many points where beneficial results, or the lack of them, will depend primarily upon one's mental attitude--his dedication to the task, willingness to act or not act, to help solve problems, and to be cooperative with others.

In short, right results require right mental attitudes. If everyone is honestly and effectively dedicated to Stream Corridor Improvement, we will achieve it. And if not, we will never get it.

Now, with the correct Mental Attitude we can talk some about those aspects of Design that may be affected or modified by a commitment to reduce disturbance to soils and water during the improvement of channels.

As always, regardless of the size of the job, a set of plans and specifications that delineate the work required, as determined by the design, is needed. And the design must be based upon an analysis of pertinent basic data. In looking at basic data needs, there are several items that may usefully warrant intensification.

1. Surveys. These need to be not only accurate, but also complete; i.e., all points of present or potential erosion must be known. Especially important are stream junctions, bridges, and side inlet locations.

2. Photo Maps. These are very useful. The use of a good sharp photo base for plan views will show much detail not ordinarily available; such as trees, vegetative cover, land use and even stream factors important to fish and wildlife (see Figure 1). If property lines are shown, they could be invaluable in the selection of odd lots and corners for habitat preservation.

3. Soils and Geology. Always important but more so now if we are to precisely analyze erosion potentials, vegetative cover preservation or replacement, and give proper consideration to other environmental factors.

4. Planned Land Use--now and future. This vital data is needed to control the sizing, location, and type of channels and appurtenant measures.

5. Environmental Factors. A complete inventory of these factors is equal in importance to survey data, and it needs to be available early. Although we haven't yet used it, the "Matrix System" proposed in Geological Survey Circular 645 appears to have considerable merit.

With basic data in one hand, we need criteria in the other before we can stir up a design. Among the many items of criteria we normally use, there are two that bear emphasis. These are:

1. Required Capacity. This should be the near minimum to meet planned land use. The larger the capacity, the more earth disturbance there will be and more chance for erosion.

2. Functional Requirements. In addition to major purpose, there will be many subsidiary needs related to erosion control and environmental values that will influence design; i.e., preservation or provision of fish and wildlife habitat. Anything required by policy, procedures, or common sense should be listed as these are related to the type of design and an accurate comparison of alternative costs.

With data and criteria at hand, let's look at some of the more important parts of a design.

First, there are two big important interdependent items that must be paid particular attention. These are alignment and cross sections.

Although the day of the relative straight clean-cut channel is not past, their use is, and properly so, being restricted.

Until a very few years ago, designers were bound in a straight jacket composed of training, experience, tools, techniques, and time. Tedius calculations by use of tables, slide rules, and desk calculators virtually guaranteed clean-cut, uniform flow designs. These resulted in some unnecessary earth disturbance.

With electronic computers and appropriate programs, we now have the flexibility to analyze all sorts of channel alternatives with nonuniform flow variables, the combination of which if done by the old methods could have kept a designer busy on one job for years. The use of these computers can reduce both costs and earth disturbance. However, it isn't easy. An experienced designer, with an eye for alternatives and an ability to judge a computer's output, is a prerequisite to meaningful results.

From an alignment standpoint - If a channel is to be lined, perhaps it ought to be straight. But an improved earth channel can and generally should fit smoothly the corridor it traverses. A curvaceous natural channel is a thing of beauty that can be improved with a minimum amount of earth disturbance.

From a cross sectional standpoint - Each section that can be left alone will result in less total earth disturbance. Rather than forcing a fit to a template, whenever practical we can and should use an electronic computer to search through alternatives of varied locations and natural cross sections to find an adequate solution, with a minimum of disturbance, to meet all functional and environmental objectives.

As alignment and cross sections are firmed up, there is a need to select and size appurtenant structures. Chapter 6 of the Engineering Field Manual gives a good treatment of the types of structures available, together with the functional uses, adaptability, advantages and limitations of each. In our mind some of the most important types of structures are:

1. Gradient Control - To preserve a stable non-erosive bottom grade.

2. Streambank Protection - To protect curves, preferably of rock riprap.

3. Crossings - Not only bridges and culverts but also fords of concrete or rock to prevent mud stirring and erosion.

4. Junctions - Concrete or rock to provide non-erosive transitions.

5. Side Inlets - To provide non-erosive transfer of surface water to the channel at each and every point where needed.

A complete and meticulous treatment of the foregoing is necessary to prevent erosion and stop pollution from sediments.

In addition, during design a notation of the need for and a selection of foreseeable temporary measures such as trash collectors, debris basins, and diversions should be made.

Along with structural measures, and of equal importance, are measures for vegetative and woody plant management and enhancement. This includes

existing material (trees, shrubs, and grass) to be left alone, and items that are to be added. This is very important in reducing the amount and duration of earth disturbance.

Incidentally, we feel that it is extremely important that all planned measures, including plantings, be included in one construction contract in order to have a coordinated approach that reduces erosion hazards to the minimum. It makes no difference to a streambank whether you intend to protect it with rock or grass. The important thing is to have the selected protection in place as quickly as possible; and if grass is used, in some cases irrigation may be necessary.

In Oregon we have, since last year, been including the vegetative work in the construction contract. This has been done on 11 jobs that involved 29 miles of channels and 300 acres of seedings. The results have been very good. An example of the specifications we have developed for vegetative work, and general pollution control, is attached as Exhibit 1.

In doing this kind of work, there will be many opportunities to select measures that have multiple benefits. For example, earth spoil can be mounded to reduce size of spoil areas and also improve wildlife habitat. Likewise, the types of mulches, such as wheat or barley straw, used to protect grass seedings on cut areas might help wildlife.

At this point, and probably several times at earlier stages, the evolving preliminary design must be carefully considered by the entire group (team) of people concerned. In doing this, four important items are:

1. All disciplines that can contribute must be involved; i.e., geologists, soil scientists, foresters, biologists, agronomists, archaeologists, engineers, etc.

2. All work must be considered jointly with the landowner's objectives and in keeping with environmental requirements.

3. The timing should be reasonable. It must be done while there is still ample time to make necessary changes in the design.

4. All alternatives must be explored and the best one selected.

After needed revisions, hopefully it is time for completion of plans and specifications.

The <u>plans</u> must be complete, factual and accurate, and clearly show all work needed to meet the objectives both during and after construction. This will include, of course, both permanent and temporary measures for erosion control.

The <u>specifications</u> must portray the quality of the work required. In addition, their details must firm up any methods, timing, sequence, or direction of construction that is critical; i.e., working a channel from the upstream down or in broken segments may be advantageous to stop the

movement of sediments, or the type of equipment allowed within the wetted perimeter of the channel might need to be restricted to draglines. All such requirements considered essential should be specified.

Now having finished the design, let's look at the Installation of the job.

Hopefully, with an adequate design and specifications, a good fast contractor who is also a good housekeeper and the right climatic conditions, the job may move along in good shape with a minimum of earth and water disturbance, and in many cases it will.

However, it will be helpful to point out pertinent pollution control measures to prospective bidders at site showings and make sure that they are discussed with the contractor at the pre-construction conference. It must be recognized, by all concerned, that delineated items of work and subsidiary items related to pollution control are equal in importance to any other feature of the job. The bid costs reflect this work and it must be adequately done in a timely manner.

During the progress of installation, circumstances may, and probably will, arise that necessitate changes; i.e., weather conditions could require a shut down if continued work would cause erosion, or the contract may need to be changed to temporary seedings or mulching if work cannot be completed in a timely manner.

In short, adherence to plans and specifications with adaptation to changed conditions is the key to a successful installation.

After the installation is complete, there is still a multitude of useful things to be done in Operation and Maintenance. O&M is important from at least three standpoints.

1. <u>Functional Operation</u> - Controllable facilities must be operated as designed; i.e., flashboard used to hold or divert water during dry periods can, if left in place, cause erosion or block fish movement.

2. <u>Timely Inspections</u> - They are the only way to find existing or incipent erosion, and identify structures or vegetation in need of repairs.

3. <u>Prompt Repair Work</u> - This is essential to check or preclude deterioration that is or can cause troubles; i.e., existing rock riprap may need strengthening or earth sections may require rocking. Plugged culverts, if not cleaned, may wash out completely. Vegetation may be in need of fertilizer.

At this time, I am going to show you a few slides from Oregon that will illustrate some of the things I have been talking about.

Now to briefly summarize what you have heard and seen. It's evident that we feel that the pollution abatement related to channel work cannot be treated separately from the whole concept of Stream Corridor Improvement. It involves team work at all stages with everyone:

1. Having a positive mental attitude.

2. Working to get a design that fits the stream corridor, provides minimum earth disturbance, and includes needed structures or construction methods.

3. Cooperating to secure a neat orderly installation.

4. Following up to see that the job is kept up in a good and timely manner.

Doing all of this will take more time and in many cases cost more. But we must make more and faster progress in this work. All of us have everything to gain and nothing to lose by doing a better job on Stream Corridor Improvement.

<u>SLIDES</u>

1. Small stream, Eastern Oregon. Streambank protection provided through use of rock riprap.

2. Little Muddy Creek, Willamette Valley. Unimproved channel with sparse vegetation.

3. Little Muddy Creek, Willamette Valley. Unimproved channel with heavy vegetation.

4. Little Muddy Creek, Willamette Valley. Winter view of unimproved but stable channel.

5. Lower Amazon-Flat Creek Watershed. Erosion of side drainageway.

6. Lower Amazon-Flat Creek Watershed. Recently constructed Channel A in foreground. Side channel A-1 to be improved later should have had temporary structure.

7. Beaver Creek Watershed, January 1966. Aerial view showing overland flow, ponding, and erosion of side channel junction.

8. Beaver Creek Watershed, May 1966. Turbidity problem. Temporary check dam to settle sediment while dragline was digging above. Dozer shaping on banks contributed to problem. Turbidity overloaded paper mill filtration plant and they switched to brown paper until construction was completed.

9. Lower Amazon-Flat Creek Watershed - Channel H. Clearing, snagging and shaping job.

10. Little Muddy Creek, Upper Willamette RC&D. Aerial view in May 1971. Phase I in upper screen was completed in 1969. All trees within right-of-way were cleared. Start of Phase II in lower part of photo.

11. Little Muddy Creek, aerial view. More trees were left within right-of-way of Phase II.

12. Little Muddy Creek, aerial view. Nature Conservancy of 80 acres was virtually undisturbed except for lower end.

13. Little Muddy Creek, Highway 99, fall. Work under bridge was last job on Phase II.

14. Little Muddy Creek, spring 1971. Looking downstream. Rock riprap used for streambank protection.

15. Little Muddy Creek. Completed channel as it leaves Nature Conservancy. Mulched and seeded.

16. Little Muddy Creek. Phase II work completed and channel seeded and mulched.

17. Little Muddy Creek. Phase II, side inlet.

18. Central Improvement District, Upper Willamette RC&D. Grouted rock drop with pleasing esthetics.

19. Lower Amazon-Flat Creek Watershed. Lower end of Channel A with vegetation well established.

20. River Road Project, Upper Willamette RC&D, November 1969. Completed channel with established vegetation including shrubs and trees.

21. America the Beautiful, North Carolina. A simple but pleasing stream corridor.

CONSTRUCTION SPECIFICATION

200. VEGETATING STRUCTURES

1. SCOPE

The work shall consist of site preparation and the furnishing and applying of the specified materials to establish permanent vegetation at the designated locations.

2. MATERIALS

Materials for permanent vegetation shall be as shown in paragraph 9, Items of Work and Construction Details, and unless otherwise specified shall meet the requirements of Material Specification 300, Materials for Permanent Seedings.

3. NOTICE OF PROCEDURE

The Contractor shall give the Contracting Officer at least 2 days notice of the time and place of starting his operations and shall continue to advise as to his schedule of operations.

4. SEEDBED PREPARATION

No seedbed will be prepared on slopes of 1 1/2 to 1 or steeper. On slopes that are less steep than 1 1/2 to 1, the surface of areas to be seeded shall be adequately loosened (1 to 2 inches deep) and smoothed. On stony sites, the type of equipment and the operations shall be controlled to prevent loosening excessive amounts of large rock.

Foreign vegetation and stone brought to the surface by discing and which will interfere with seeding or mowing, shall be removed from the area.

Seedbed preparation shall be suspended when soil moisture conditions are not suitable for the preparation of a satisfactory seedbed as determined by the Contracting Officer.

5. SEED APPLICATION

The methods of seed application shall be as prescribed in the Items of Work and Construction Details. The seed shall be applied uniformly on the prepared areas at the rates set forth in the Items of Work.

The several kinds of seed when more than one kind is to be used may be mixed together in the required proportions and used as a seed mixture.

a. Seedings on all slopes 3 to 1 and flatter shall be done with a grass or grain drill at 1/4 inch depth in rows 4 to 14 inches apart. On slopes steeper than 3 to 1, seedings shall be made

by hand or machine broadcasting. Broadcast seed shall be covered about 1/4 inch deep by light spike-tooth harrowing or similar method unless applied in the mulch.

b. In hydro-seeding method of application, all materials shall be applied by hydraulic-type equipment that provides continuous mixing and agitating action to a mixture of water, fertilizer, seed, and/or mulch. The mixture shall be applied through a pressure-spray distribution system providing a continuous, non-fluctuating discharge and delivery of the mixture in prescribed quantities uniformly on the specified areas. Seedbed preparation, if required, shall be as specified in Section 9, Items of Work and Construction Details.

c. In pneumatic seed application, all materials shall be applied by blower-type equipment using air pressure and adjustable disseminating device whereby dry fertilizer and dry seed shall be applied in prescribed quantities uniformly on specified areas. Seedbed preparation, if required, shall be as specified in Section 9, Items of Work and Construction Details.

d. By helicopter equipment with hoppers and adjustable disseminating mechanisms whereby seed will be applied in prescribed quantities.

e. By hand operated mechanical spreaders or seeders whereby dry seed will be applied in prescribed quantities uniformly on specified areas.

6. FERTILIZING

Fertilizer not applied with other material shall be applied separately and uniformly to the entire area to be seeded. Lime, if specified, will be applied at specified rates and thoroughly incorporated into the sod as soon as possible after being applied.

7. MULCHING

a. The kind of mulch shall be as specified. Mulchs shall be applied uniformly to the areas as soon as possible after seeding if not applied with the seed. Mulch will be applied to seeded areas not later than 2 work days after seeding has been performed.

b. Stabilizing Materials

(1) Asphalt emulsion, when specified, shall be applied uniformly over the mulch at the rate of 200 gallons per acre, or by injecting the designated asphaltic materials into the straw, as the straw leaves the mulch spreader, at the rate of 100 gallons per ton of straw.

(2) A weighted disc harrow, when specified, shall be used to stabilize or anchor the mulch. The disc harrow with the discs set straight shall be run over the mulched areas on

the contour. Only enough weight shall be used to adequately anchor or imbed a part of the straw mulch into the soil.

(3) When jute matting is specified for stabilizing the mulch, it shall be installed in accordance with manufacturer's instruction.

8. MEASUREMENT AND PAYMENT

1. The surface areas seeded will be measured to the nearest 0.1 acre. Payment for seeding will be made at the contract unit price established in the bid schedule and shall constitute full compensation for all labor, materials, equipment and incidentals necessary to the completion of the work, including seedbed preparation, seed, inoculant and fertilizer.

2. Jute matting will be measured to the nearest square yard of surface area covered. Payment will be made at the contract unit price and shall constitute full compensation for all labor, equipment, materials and other items necessary and incidental to the completion of work, including the matting and necessary anchors.

3. Mulching will be measured to the nearest 0.1 acre. Payment for mulch will be made at the contract price established in the bid schedule and shall constitute full compensation for all labor, materials, equipment and other items necessary to the completion of the work, including the application of asphalt emulsions or use of equipment for anchorage.

4. Payment for furnishing and applying seed, fertilizer and mulch by hydraulic method will be measured to the nearest 0.1 acre surface area measured. Payment for hydro-seeding will be at the contract unit price and shall constitute full compensation for all labor, materials, equipment and incidentals necessary to the completion of the work.

Compensation for any items of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items, and the items to which they are made subsidiary, are identified in section 9 of this specification.

9. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 21, Seeding

(1) This item shall consist of seeding the slopes of the channel and disturbed areas within the right-of-way and the construction permit limits as directed by the Contracting Officer and in accordance with these contract specifications.

(2) The seedbed shall be prepared by loosening uniformly to 2" deep with a disc or spike-tooth harrow or similar tillage equipment that will not dislodge rocks.

(3) In Section 5, Seed Application, use Method a, b, or c.

(4) All areas to be seeded shall be fertilized at the following rate of available nutrients:

Nitrogen	80 lbs/acre
Phosphoric Acid	80 lbs/acre
Potash	80 lbs/acre

(5) All areas to be vegetated shall be seeded with one of the following mixtures applied at the specified rates.

(a) Mixture 1 - (Sta. 263+89 to 398+75)

Pennlawn Creeping Red Fescue	15 lbs/acre
Fawn Fescue	25 lbs/acre
Cascade or Granger Birdsfoot trefoil	10 lbs/acre
Winter Barley	10 lbs/acre

(b) Mixture 2 - (Sta. 398+75 to 452+76.77)

Pennlawn Creep Red Fescue	30 lbs/acre
Linn Perennial Ryegrass	8 lbs/acre
Cascade or Granger Birdsfoot trefoil	10 lbs/acre
Winter Barley	10 lbs/acre

(6) Measurement and payment will be by Method 1.

b. Bid Item 22, Mulching

(1) This item shall consist of mulching the channel side slopes.

(2) The straw mulch shall be as specified in Material Specification 300, Permanent Seedings, Section 6.a, Straw Mulch.

(3) Mulch shall be applied at the rate of 2 1/2 tons per acre immediately after seeding and fertilizing.

(4) Measurement and payment will be by Method 3.

CONSTRUCTION SPECIFICATION

203. POLLUTION CONTROL

1. SCOPE

The work shall consist of special precaution taken on construction projects to reduce or eliminate air and water pollution for the general improvement of our environment. Therefore, certain requirements and restrictions are included in this contract. In so far as practical, soil erosion and pollution control and abatement shall be carried out concurrently with the contract construction acitivities to insure that acceptable control is in effect at all times.

Construction shall be carried out so that air pollution is held to a minimum and in conformance with the requirements of all related laws and codes.

2. WET WEATHER

Construction acitivities shall not be carried out during extended periods of wet weather unless measures are taken to control or prevent soil erosion and water pollution.

3. LIMIT TRANSPORTATION ROUTES

Work areas and transportation routes for materials, men or equipment to or within the project area shall be limited to those roads or areas needed.

4. WATER POLLUTION

Soil erosion on construction sites or pollution of live streams, lakes, ponds, springs, irrigation or drainage channels, or other water sources will be prevented or reduced to acceptable limits.

Work on the channel or banks of creeks, ponds, or lakes shall be prohibited or limited to the work actually specified to be done. Turn areas, roads, parking areas, temporary building sites, etc. shall not be constructed within the channel or on the channel banks but shall be placed at a location to prevent contamination of the water or the destruction of game or fish habitat.

Where access or construction roads cross existing streams, temporary culverts or bridges of adequate size shall be installed as shown on the drawings or approved by the Contracting Officer.

Exposed cut slopes, embankment slopes, borrow areas or other disturbed areas, when specified, shall be protected with permanent vegetation as soon as practical after slopes are finished, borrow areas are exhausted, or as directed by the Contracting Officer. Vegetative treatment shall be as specified under Construction Specification 200.

Diversion dikes or ditches, downslope gutters, pipelines, etc. for water control or disposal shall be installed as shown on the drawings and staked in the field.

The Contractor shall provide tanks or barrels or construct a sump sealed with plastic sheets to be used to dispose of chemical pollutants produced as a by-product of the projects work such as drained lubricating or transmission oils, greases, soaps, asphalt, etc. At the completion of the construction work, the sump shall be covered or filled as directed by the Contracting Officer. Storage tanks or barrels shall be removed from the site.

Sanitary facilities such as pit toilets, chemical toilets, or septic tanks shall not be placed adjacent to live streams, wells, or springs. They shall be located at a distance sufficient to prevent contamination of any water source.

5. AIR POLLUTION

Local and state regulations concerning the burning of brush or slash or disposal of other materials shall be adhered to.

Fire prevention measures shall be taken to prevent the start of fires or the spread of fires which result from project work. Fire breaks or guards shall be constructed at locations as shown on the drawings.

All public access or haul roads used during construction of the project shall be sprinkled as required to fully suppress dust.

6. MEASUREMENT AND PAYMENT

For items of work for which specific lump sum prices are established in the contract, payment for pollution control will be made at the contract lump sum prices. Such payment will constitute full compensation for all labor, equipment, tools, and all other items necessary and incidental to the completion of the work.

Compensation for any items of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 7 of this specification.

7. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Subsidiary Item, Pollution Control

(1) This item shall consist of work done to prevent water and air pollution during construction.

(2) Section 4, Water Pollution, and Section 5, Air Pollution, shall apply.

(3) In the event burning is not permitted, all material shall be buried in the construction permit waste areas shown on the drawings or disposed of at other locations approved by the Contracting Officer. Buried material shall have a minimum cover of three feet.

(4) No separate payment will be made for pollution control. Compensation for pollution control will be included with payment for Bid Items 2 and 4.

MATERIAL SPECIFICATION

300. PERMANENT SEEDINGS

1. SCOPE

The specification covers the quality of materials to be used in vegetating structures.

2. SEED

All seed shall be certified blue tag and from the latest crop available. Seed shall be labeled in accordance with state laws and the U. S. Department of Agriculture rules and regulations under the Federal Seed Act in effect on the date of invitations for bids. Bag tag figures will be evidence of purity and germination. No seed will be accepted with a date of test of more than 9 months prior to the date of delivery to the site.

Seed that has become wet, mouldy, or otherwise damaged in transit or storage will not be accepted. The percent of noxious weed seed allowable shall be as defined in the current state laws relating to agricultural seeds. Each type of seed shall be delivered in separate sealed containers and fully tagged unless exception is granted in writing by the Contracting Officer.

3. LIME

Lime shall consist of Standard Ground Agricultural Limestone or approved equivalent. Standard Ground Agricultural Limestone is defined as ground limestone meeting current requirements of the State Department of Agriculture.

4. INOCULANT

The inoculant for treating legume seeds shall be a pure culture of nitrogen-fixing bacteria prepared specifically for the species and shall not be used later than the date indicated on the container or as otherwise specified. A mixing medium as recommended by the manufacturer shall be used to bond the inoculant to the seed. Inoculation of legumes shall be done within 48 hours before seeding.

5. FERTILIZERS

Fertilizers shall include nitrogen, phosphate and potassium. Fertilizers shall be free flowing, suitable for application with hydraulic or pneumatic type equipment, or fertilizer spreaders, delivered to the site in bags or other convenient containers; each fully labeled, conforming to applicable state fertilizer laws, and bearing the name, trade names or trademarks, composition, and warranty of the producer. Caked or lumpy fertilizer will not be accepted.

All fertilizer shall be in a form readily available to plants.

6. MULTCH

a. Straw Mulch

Straw mulch shall be the chopped or broken stalks (4 to 10 inches long) of slender vegetative growth such as hay or straw from grass seed harvest as approved by the Contracting Officer. Bent and common rye grass straw shall not be used. Weed seed content should be at an acceptable level with no noxious weed seeds present. Mulching machinery must be such that mulch can be applied in a uniform manner. Straw mulch shall not be musty, mouldy, caked, decayed, or of otherwise low quality.

b. Wood Cellulose Fiber Mulch

Wood cellulose fiber mulch shall consist of a specially prepared wood fiber processed to contain no growth or germination inhibiting factors. The fiber mulch shall be manufactured and processed in such manner that the wood cellulose fibers will remain in uniform suspension in water under agitation and will blend with grass seed fertilizer and other additives to form a homogeneous slurry. The processed mulch material shall have characteristics to form a blotter-like ground cover on application, having moisture absorption and percolation properties and the ability to cover and hold grass seed in contact with soil. The wood cellulose fiber mulch material shall be shipped in packages of uniform weight (plus or minus 5%) and bearing the name of the manufacturer and air-dry weight content. Suppliers shall certify, upon request of the Contracting Officer, that laboratory and field testing of their product has been accomplished and that it meets the foregoing requirements and intent.

7. STABILIZING MATERIALS

a. Asphalt Emulsion

Asphalt emulsion shall be gasoline, (naptha) cutback asphalt MC-2 or MC-3, or Emulsified Asphalt SS-1, SS-2, or MS-2, meeting the requirements of the Asphalt Institute.

b. Jute Matting

Jute matting shall be of a uniform open plain weave of undyed and unbleached single jute yarn. The yarn shall be of loosely twisted construction and shall not vary in thickness by more than 1/2 its normal diameter. Jute matting shall have a minimum width of 48 inches and shall contain 78 warp ends and 41 weft ends per yard. In any one shipment, the weight of matting shall average 1.22 pounds per linear yard for 48 inch wide matting and with proportional weight for wider matting with a tolerance of plus or minus 5%.

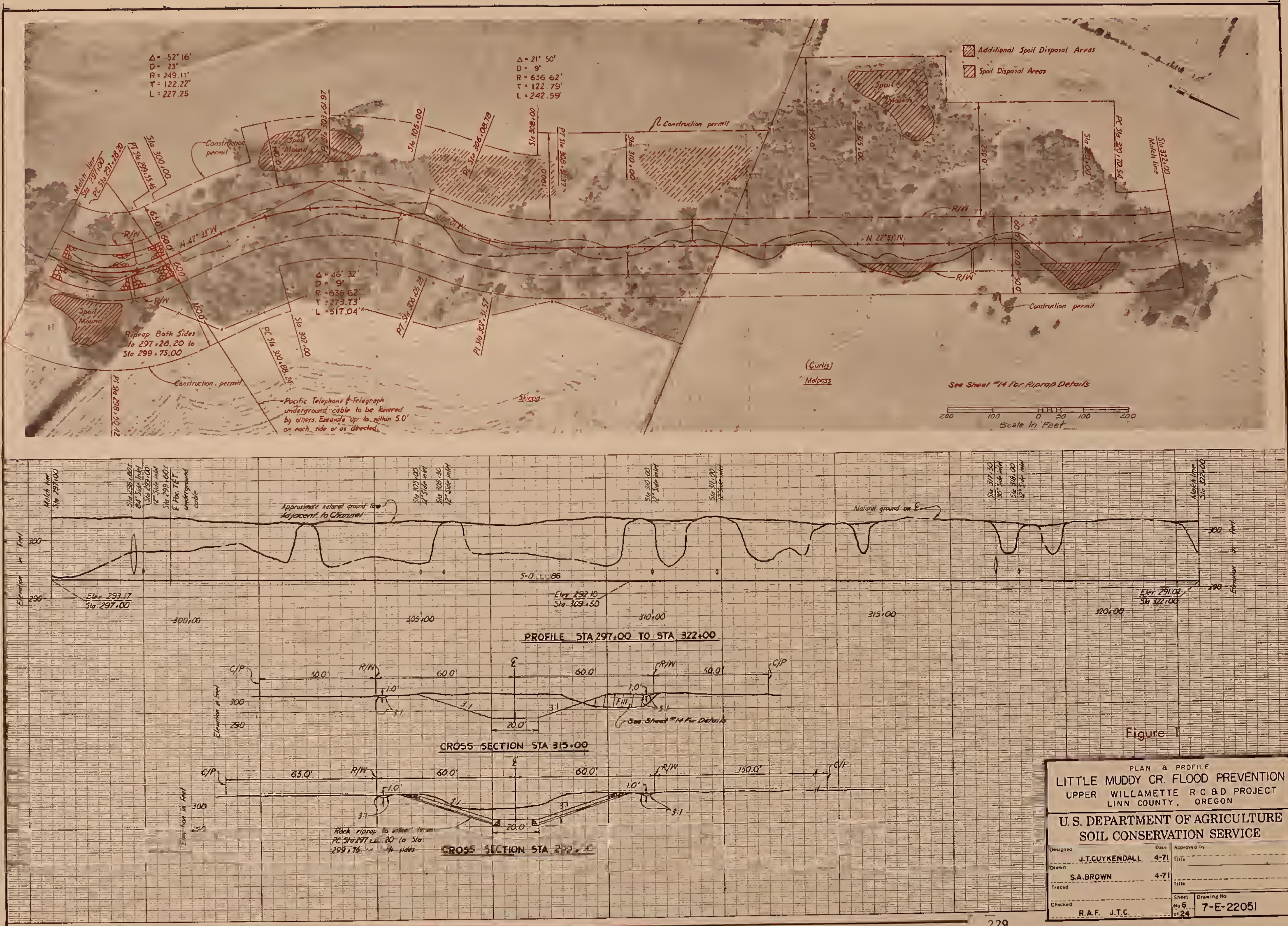
Additional Spoil Disposal Areas
Spoil Disposal Areas
Δ = 52° 16'
D = 23°
R = 249.11'
T = 122.22'
L = 227.25
Δ = 21° 50'
D = 9°
R = 636.62'
T = 122.79'
L = 242.59'
Δ = 46° 32'
D = 9°
R = 636.62'
T = 273.73'
L = 517.04'
Construction permit
Spoil Mound
R/W
N 47° 33' W
N 22° 51' W
Riprap Both Sides Sta 297+28.20 to Sta 299+75.00
Pacific Telephone & Telegraph underground cable to be lowered by others. Excavate up to within 5.0' on each side or as directed.
See Sheet #14 For Riprap Details
Scale In Feet
PROFILE STA 297+00 TO STA 322+00
Approximate natural ground line Adjacent to Channel
Natural ground on ℄
Elev. 293.17 Sta 297+00
Elev. 292.10 Sta 309+50
Elev. 291.02 Sta 322+00
CROSS SECTION STA 315+00
See Sheet #14 For Details
CROSS SECTION STA 299+00
Rock riprap to extend from PC Sta 297+28.20 to Sta 299+75 both sides
PLAN & PROFILE
LITTLE MUDDY CR. FLOOD PREVENTION
UPPER WILLAMETTE R C & D PROJECT
LINN COUNTY, OREGON
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed J.T.CUYKENDALL 4-71
Drawn S.A.BROWN 4-71
Checked R.A.F. J.T.C.
Sheet No 6 of 24
Drawing No 7-E-22051

Figure 1